U.S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

Public Roads

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ON THE ROAD BETWEEN TEMPE AND ROOSEVELT DAM—APACHE TRAIL

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U. S. DEPARTMENT OF AGRICULTURE

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STATE HIGHWAY MILEAGES AND EXPENDITURES IN THE YEAR 1918

By ANDREW P. ANDERSON, Highway Engineer.

BASED on complete reports from 44 of the States, cash expenditures on the rural roads and bridges of the United States for the calendar year 1918 amounted to $286,098,193. To this should be added the value of statute and convict labor, which can not be fixed with any great degree of accuracy but probably amounted to not less than $14,000,000, thus making the grand total expenditures for the year $300,000,000. This total is made up of the actual expenditures for such items as labor, materials, supervision and administration directly connected with the construction, improvement, and upkeep of our public roads and bridges outside the limits of incorporated towns and cities, and does not include any item for sinking fund payments or redemption and interest on road and bridge bonds.

The year 1918 offered an unprecedented condition in practically all lines of highway work. There was not only a tremendous increase and expansion in the amount of heavy truck traffic on our public roads and an unprecedented shortage in regard to road materials, labor, and ready funds, but also a decided increase in maintenance work, which was, however, partially offset by a decrease in the amount of new construction.

COST OF MAINTENANCE INCREASED.

The most striking single development through the year was the tremendous increase in motor truck traffic. Five years ago heavy motor trucks were few in number and limited practically entirely to the paved streets of our larger cities. These vehicles now comprise probably 4 to 5 per cent of the grand total of all our motor vehicles and are to be found wherever traffic conditions permit of their profitable use. But very few of our present roads were designed to carry any large volume of this class of traffic. Consequently, the cost of adequate maintenance was increased greatly during the year. In many places the damage due to the incessant pounding of these fast and heavy vehicles was so great as to require complete reconstruction.

The undertaking of new construction work was of necessity deferred to a large extent during 1918. However, in spite of a sadly reduced and broken organization due to the demands of the war, there continued throughout the year among the several State highway departments a decided forward looking movement to the time when hostilities should be ended. This movement consisted largely in formulating definite plans for the renewal of all lines of activities on an increased scale at the earliest possible moment. Thus, Illinois and Pennsylvania each voted bond issues providing for the construction of a comprehensive system of State roads with the understanding, however, that none of the money should be expended until after the war had closed.

VAST SUMS FOR ROADS.

The full effect of this movement, however, did not become apparent until the early part of 1919, when state and county governments began to make provision for road funds to an extent entirely unknown before. Thus, between November 1, 1918, and July 1, 1919, state highway bonds were voted as follows: Illinois, $60,000,000; Pennsylvania, $50,000,000; Michigan, $50,000,000; California, $40,000,000; Oregon, $12,500,000; South Dakota, $4,500,000; Utah, $4,000,000; Wyoming, $2,800,000; Nevada, $1,000,000; or a total of $224,800,000. Other States have made definite provisions for submitting to a vote of the electors between June 30, 1919, and December 31, 1920, bond issues as follows: Minnesota, $75,000,000; Texas, $75,000,000; Missouri, $60,000,000; West Virginia, $40,000,000; Washington, $30,000,000; Montana, $15,000,000; Maine, $10,000,000; Colorado, $5,000,000; Idaho, $2,000,000; and New Mexico, $2,000,000, or a total of $314,000,000. Alabama, Georgia, and Virginia are each contemplating making provisions for submitting the question of issuing state highway bonds to the voters.

On May 6, 1919, the electors in Oklahoma defeated a state road bond issue providing for $50,000,000. In New York the question of submitting to the voters a provision for issuing $20,000,000 in road bonds was vetoed by the governor, as was also a provision for authorizing $20,000,000 in the State of Arizona.

INCREASE IN FEDERAL AID.

The Federal Government also made provision for a considerable increase in the amount of funds available under the Federal aid road act of July 11, 1916, for the improvement of rural post roads and forest roads. The Post Office appropriation act approved February 28, 1919, carried an amendment to the above act which provided for an additional appropriation of $209,000,000 for Federal cooperation

in the improvement of rural post roads and forest roads to be available during the years 1919, 1920, and 1921.

Definite data are not available as to the amount of county, town, district, and other forms of local road bonds which have been voted during the period covered by this investigation. There is, however, abundant evidence that this total far exceeds that already voted by the several States. Many of the State Governments, as well as local communities, have also made provisions for considerable increase in their regular road and bridge revenues or have discovered new sources of such revenues. A large number of the States have materially increased the direct road taxes as well as the registration fees of motor vehicles. Three States—Colorado, New Mexico, and Oregon—have also placed a tax on the sale of gasoline, the income from which is to be used for road purposes.

TABLE I.—EXPENDITURES DURING THE YEAR 1918, BY OR UNDER THE SUPERVISION OF THE STATE HIGHWAY DEPARTMENT.

State.	Funds.				Distribution of expenditure.						State funds available, 1919 (approximate).	Local road and bridge expenditures, 1918, not under State highway department (approximate).
	Federal.	State.	Local.	Total.	Construction.		Maintenance, roads and bridges.	Engineering.	Administration.	Equipment and miscellaneous.		
					Roads.	Bridges.						
Alabama	$133,380.90	$103,285.32	$134,547.20	$371,213.42	$314,163	$27,230	...	$18,262	$11,559	...	$350,878	$2,000,000
Arizona [1]	31,947.35	975,801.95	10,000.00	1,017,749.30	608,677	191,093	$82,255	68,285	44,552	$22,888	1,500,000	1,000,000
Arkansas	41,778.52	221,831.24	...	263,609.76	229,997	16,304	...	9,808	7,500	...	700,000	1,700,000
California	26,399.00	6,941,192.00	29,179.00	6,996,770.00	5,237,420	(2)	894,921	324,720	234,392	305,317	6,500,000	[3] 14,649,868
Colorado	250,000.00	800,000.00	400,000.00	1,450,000.00	410,000	120,000	800,000	(4)	100,000	20,000	1,000,000	1,850,000
Connecticut	5,301.15	3,172,706.35	396,600.08	3,574,607.58	1,640,707	295,927	1,256,565	165,023	23,285	193,101	4,000,000	1,444,212
Delaware	5,268.40	429,734.43	208,373.86	643,376.69	606,606	8,050	2,153	24,632	1,936	...	1,500,000	300,000
Florida	9,972.55	179,807.22	328,722.38	518,502.15	389,111	3,664	80,092	33,321	8,196	4,118	732,430	5,245,703
Georgia	21,158.00	15,000.00	55,898.00	92,056.00	72,368	800	...	18,888	(5)	...	15,000	5,700,000
Idaho	48,936.00	491,342.00	479,642.00	1,019,920.00	651,033	133,796	115,540	93,423	22,384	3,744	1,000,000	2,500,000
Illinois	...	860,910.99	1,216,312.87	2,077,223.86	1,787,357	59,669	65,557	129,030	30,911	4,700	10,000,000	8,106,129
Indiana	...	...	...	...	...	...	...	...	...	...	4,000,000	13,000,000
Iowa	75,853.12	113,488.49	14,360,280.61	14,549,622.22	2,931,526	4,972,168	4,158,254	453,870	(5)	2,033,804	4,000,000	...
Kansas	8,083.90	25,000.00	1,922,766.10	1,955,850.00	131,250	1,600,600	...	225,000	(5)	...	25,000	3,061,267
Kentucky	...	1,000,000.00	580,000.00	1,580,000.00	1,100,000	300,000	60,000	65,000	25,000	30,000	1,500,000	1,800,000
Louisiana [1]	...	182,295.00	358,681.00	540,976.00	430,708	35,984	9,841	42,107	20,060	2,276	200,000	3,000,000
Maine	81,611.96	1,570,493.75	707,309.05	2,359,414.76	1,333,776	263,500	613,805	60,129	42,941	45,265	2,010,000	1,500,000
Maryland	4,767.73	2,681,141.89	64,225.50	2,750,135.12	1,064,674	105,875	1,368,860	68,601	24,425	117,700	3,800,000	3,000,000
Massachusetts	33,440.00	3,522,493.89	568,369.00	4,124,302.89	1,389,153	3,150	2,365,794	188,688	60,535	116,984	4,597,500	5,000,000
Michigan [1]	...	1,704,359.00	3,968,794.00	5,673,152.00	5,125,224	187,751	247,178	62,000	43,000	8,000	2,000,000	5,000,000
Minnesota	224,357.76	1,870,336.01	3,300,216.08	5,394,909.85	3,146,867	942,119	1,000,867	(4)	305,057	...	2,529,049	5,172,801
Mississippi	...	10,000.00	...	10,000.00	...	...	...	2,500	7,500	...	10,000	750,000
Missouri	...	704,400.00	450,000.00	1,154,400.00	900,000	...	181,000	17,600	38,800	17,000	3,000,000	6,000,000
Montana	...	133,547.77	...	133,547.77	36,987	27,767	...	32,095	6,100	30,600	200,000	3,791,402
Nebraska	41,866.21	201,202.44	112,759.72	355,828.37	61,103	193,448	32,072	13,396	50,483	5,327	3,708,000	3,500,000
Nevada	...	75,327.59	...	75,327.59	...	...	16,467	21,581	20,638	16,642	650,248	399,442
New Hampshire	20,530.23	651,593.70	332,561.21	1,004,685.14	334,985	...	593,549	26,484	31,904	17,763	900,000	1,000,000
New Jersey [6]	...	1,848,932.41	1,860,000.00	3,708,932.41	606,587	...	2,800,922	87,321	114,696	99,407	5,500,000	3,000,000
New Mexico	...	527,071.57	487,120.53	1,014,192.10	487,261	96,912	249,284	39,587	6,085	135,063	1,205,000	300,000
New York [1]	...	9,432,679.00	2,282,452.00	11,715,130.65	5,635,027	...	4,537,709	1,108,622	273,874	159,899	14,000,000	9,000,000
North Carolina [1]	...	20,000.00	...	20,000.00	...	...	...	(4)	20,000	...	300,000	4,000,000
North Dakota	71,000.00	83,000.00	54,000.00	208,000.00	115,000	28,000	600	29,500	34,900	...	3,000,000	3,000,000
Ohio	169,075.76	4,670,270.22	3,660,487.75	8,499,833.73	6,272,840	(2)	1,791,244	200,926	133,584	101,239	4,000,000	6,000,000
Oklahoma	...	1,046,892.75	1,577,610.01	2,624,502.76	998,865	527,422	670,726	168,200	17,512	241,776	1,212,000	507,029
Oregon	...	2,120,551.24	709,724.79	2,830,276.03	1,948,936.	617,388	...	162,384	63,491	38,076	5,000,000	4,000,000
Pennsylvania	137,437.17	[7] 8,041,833.86	574,605.09	8,753,876.12	1,694,011	279,359	5,473,193	227,335	260,267	[8] 819,711	16,000,000	6,000,000
Rhode Island	34,997.13	745,673.91	...	780,671.04	...	109,696	600,720	44,634	10,000	15,622	800,000	355,000
South Carolina	50,754.92	49,238.61	40,911.87	140,905.40	113,921	2,746	...	[9] 14,022	8,961	1,255	275,000	1,535,334
South Dakota	...	30,473.35	1,236.18	31,709.53	6,831	...	...	14,007	10,871	...	2,000,000	3,000,000
Tennessee	...	403,000.00	75,000.00	478,000.00	38,000	...	400,000	20,000	20,000	...	1,800,000	2,500,000
Texas	95,510.65	295,567.38	1,934,648.72	2,325,726.75	901,391	...	1,306,336	85,000	33,000	...	1,900,000	9,000,000
Utah	...	1,546,842.53	60,417.72	1,607,260.25	845,929	85,961	231,341	108,892	72,594	262,543	3,000,000	1,163,231
Vermont	5,000.00	778,075.00	223,000.00	1,006,075.00	494,000	55,000	445,000	2,075	10,000	...	800,000	600,000
Virginia	24,516.57	861,030.69	1,322,804.80	2,208,352.06	1,251,561	138,945	695,537	68,793	51,435	2,082	1,660,000	1,500,000
Washington	128,439.10	2,922,436.11	205,430.45	3,256,305.66	2,520,574	152,576	559,768	(4)	23,388	...	5,000,000	4,000,000
West Virginia	42,782.17	171,581.32	342,090.76	556,454.25	444,659	72,838	17,758	11,800	9,400	...	1,290,000	4,500,000
Wisconsin	225,319.00	2,051,455.00	3,307,401.00	5,584,175.00	3,175,126	993,966	1,250,000	(4)	165,083	...	2,500,000	3,700,000
Wyoming	59,053.61	67,582.26	121,071.74	247,707.61	163,198	17,773	...	39,146	11,736	15,855	2,000,000	681,507
Total and average	2,108,538.86	66,351,478.24	48,825,251.07	117,285,267.82	57,647,409	12,667,477	34,974,908.	4,596,687	2,512,035	4,887,757	133,670,105	168,812,925

[1] Data for 1917. Data for 1918 not available.
[2] Included under roads.
[3] Does not include San Francisco County.
[4] Included under administration.
[5] Included under engineering.
[6] Approximate.
[7] Does not include $943,765 State funds distributed to townships.
[8] Includes $384,975 for purchase of toll roads.
[9] Includes surveys for approximately 138 miles of proposed construction.

TERM OF ROAD BONDS.

In a few of our States the question of limiting the term of road and bridge bonds to the probable life of the improvement for which they are issued has as yet received but scant attention. The practice of issuing 30 or 40 or even 50 year bonds to pay for an improvement which can not possibly last more than one-half and probably not more than one-third or one-fourth of this period is neither good finance nor good common sense. In no case should the term of these bonds exceed the most probable life or productive period of the improvement.

Another practice which has served to cover up this evil is that of taking up road bonds on or before their maturity by means of so-called funding or refunding bonds, which almost invariably have a long term. In this way not only is the term of the debt continued for a very much longer period, but it is placed in such form as to cover or conceal its relation to the

road improvement. Consequently, the full extent of the bond burden resulting from our past road and bridge expenditures is impossible of exact determination. Estimates based on the best available data would seem to show that there are at least $400,000,000 outstanding which are actually designated as road and bridge bonds or warrants. These are at present maturing at a rate in excess of $20,000,000 per year and a like or greater amount is required annually for interest payments. For a number of year past new road and bridge bonds have been issued at the rate of about $40,000,000, per annum and while there has been a marked decrease during 1917 and 1918, there is now abundant promise of a very decided increase.

STREETS COST ABOUT $300,000,000.

The expenditures on our city, town, and village streets are not included in these compilations as no complete records are available as to their amount. However, it is estimated that the expenditures on account of our streets amount in round numbers to $300,000,000 annually, or approximately the same as that expended on our rural roads and bridges. Many ɔ ɔour city streets are in reality only extension or connecting links in our main highway systems.

TABLE II. ROAD MILEAGE.

State.	Work done in 1918 under State supervision.			Miles of rural public roads.			State.
	State and State-aid roads built, 1918.	Roads maintained with State aid, 1918.	Number of bridges built by State or State aid, 1918.	Total all surfaced roads in State (approximate).	Total all public rural roads in State.	Percentage of surfaced roads in State.	
Alabama	[1]109	...	2	6,125	55,446	11.0	Alabama.
Arizona	52	436	10	475	12,075	3.9	Arizona.
Arkansas	(2)	...	(2)	2,000	50,743	4.0	Arkansas.
California	[3]260	2,521	11	13,000	61,039	21.2	California.
Colorado	[4]100	7,000	15	2,550	39,780	6.4	Colorado.
Connecticut	[5]55	1,481	13	3,200	14,061	22.6	Connecticut.
Delaware	10	20	1	310	3,674	8.5	Delaware.
Florida	[6]77	352	1	3,900	17,995	21.6	Florida.
Georgia	17	...	2	13,200	80,669	16.4	Georgia.
Idaho	[7]90	490	12	850	24,396	3.5	Idaho.
Illinois	[8]232	736	80	12,800	95,647	13.4	Illinois.
Indiana	...	...	...	31,000	73,347	42.5	Indiana.
Iowa	[9]2,969	104,682	[10]10,237	1,500	104,074	1.4	Iowa.
Kansas	19	...	(2)	1,550	111,052	1.4	Kansas.
Kentucky	[11]214	65	150	13,900	57,916	24.0	Kentucky
Louisiana	(2)	(2)	(2)	2,700	24,563	11.0	Louisiana.
Maine	[12]160	4,235	19	3,525	23,537	14.9	Maine.
Maryland	192	1,433	5	3,100	16,459	18.8	Maryland.
Massachusetts	72	[13]2,000	1	9,100	18,681	48.8	Massachusetts.
Michigan	150	...	...	10,600	74,190	14.3	Michigan.
Minnesota	[14]1,643	12,089	[10]640	7,000	93,517	7.5	Minnesota.
Mississippi	...	...	...	2,700	45,779	5.9	Mississippi.
Missouri	[15]300	[16]11,400	...	7,550	96,041	7.8	Missouri.
Montana	[17]83	...	9	900	39,204	2.3	Montana.
Nebraska	[18]41	...	6	1,450	80,272	1.8	Nebraska.
Nevada	...	260	...	340	12,182	2.8	Nevada.
New Hampshire	[19]52	1,479	...	2,000	14,020	14.5	New Hampshire.
New Jersey	16	2,450	...	6,050	14,817	41.0	New Jersey.
New Mexico	[20]1,258	6,035	163	620	[21]43,091	1.4	New Mexico.
New York	(2)	(2)	(2)	18,400	79,398	23.2	New York.
North Carolina	(2)	(2)	(2)	6,850	50,758	13.5	North Carolina.
North Dakota	[22]110	65	...	1,160	68,796	1.8	North Dakota.
Ohio	[23]342	2,485	7	31,800	86,354	36.8	Ohio.
Oklahoma	[24]927	2,592	614	700	107,916	.7	Oklahoma.
Oregon	[25]213	...	60	5,000	36,819	14.1	Oregon.
Pennsylvania	44	8,495	167	10,600	91,556	11.6	Pennsylvania.
Rhode Island	[26]15	325	12	750	2,170	34.5	Rhode Island.
South Carolina	11	...	1	3,800	42,226	9.0	South Carolina.
South Dakota	(2)	...	...	800	96,306	.8	South Dakota.
Tennessee	12	3,800	...	8,880	46,050	19.2	Tennessee.
Texas	230	13,000	...	12,300	128,960	9.6	Texas.
Utah	109	357	...	1,650	8,810	18.6	Utah.
Vermont	110	4,300	...	2,300	14,249	16.3	Vermont.
Virginia	[27]358	3,054	39	6,150	53,388	11.7	Virginia.
Washington	[28]275	1,411	6	6,300	42,428	14.9	Washington.
West Virginia	[29]135	88	12	1,600	32,024	5.0	West Virginia.
Wisconsin	[30]735	5,000	670	15,500	77,280	20.1	Wisconsin.
Wyoming	[31]167	...	8	600	14,797	4.1	Wyoming.
Total and average	11,944	233,556	12,973	299,135	2,478,552	12.0	Total and average.

[1] Includes 12 miles of earth roads.
[2] Data not available.
[3] Includes 87 miles of earth roads.
[4] Includes 64 miles of earth roads.
[5] Includes 34 miles of reconstruction.
[6] Includes 5 miles of earth roads.
[7] Includes 75 miles of earth roads.
[8] Includes 64 miles of earth roads.
[9] Includes 2,549 miles of earth roads.
[10] Includes culverts.
[11] Includes 45 miles of earth roads.
[12] Includes 5 miles of earth roads.
[13] Includes about 792 miles of town roads.
[14] Includes 1,207 miles of earth roads
[15] Includes 245 miles of earth roads; does not include 200 miles partially completed.
[16] Dragging only.
[17] Includes 32 miles of earth roads.
[18] Includes 35 miles of earth roads.
[19] Includes 9 miles of reconstruction.
[20] Includes 1,063 miles of earth roads.
[21] As reported by State highway engineer May, 1919.
[22] Includes 100 miles of earth road.
[23] Includes 22 miles of earth roads.
[24] Includes 716 miles of earth roads.
[25] Includes 100 miles of earth roads.
[26] All reconstruction.
[27] Includes 44 miles of earth roads and 52 miles of reconstruction.
[28] Includes 140 miles of earth roads.
[29] Includes 111 miles of earth roads.
[30] Includes 373 miles of earth roads.
[31] Includes 144 miles of earth roads.

With the present tremendous development of motor truck and automobile traffic these streets become an important and vital factor in the efficient operation and functioning of our general highway system, and especially to any general plan of motor hauling involving the delivery of country produce. It is, therefore, hoped that more definite data in regard to the extent, cost, and conditions of our city streets may soon be available.

total of $2,550,000 for road and bridge work, and in 1914, thirty-one State highway departments expended $4,221,000. In 1917 every State in the Union participated and the total expenditure of State funds amounted to $47,291,000. In 1918 this had reached a total of $66,351,000.

The utilization of convict labor in road work or in the preparation of road materials under competent state supervision is coming to be a more and more

TABLE III.—CASH ROAD AND BRIDGE EXPENDITURES FOR CALENDAR YEARS 1904, 1914, 1916, 1917, AND 1918.

State.	Year in which first State-aid law passed.	State funds expended by or under State highway department.					Total cash expenditure from all sources (approximate).				
		1904	1914	1916	1917	1918	1904	1914	1916	1917	1918
Alabama	1911		$170,232	$102,422	$89,511	$103,285	$378,040	$3,949,019	$4,186,384	$2,669,022	$2,371,213
Arizona	1909			441,202	543,422	975,802	67,591	982,721	1,988,221	1,569,422	2,017,749
Arkansas	1913		115,000	55,483	80,262	221,831	681,934	1,522,696	3,443,887	3,335,262	1,963,610
California	1895	$11,251		4,285,964	3,058,036	6,941,192	2,157,396	19,171,985	20,392,434	18,245,200	21,646,638
Colorado	1909		391,274	607,628	703,000	800,000	635,395	1,937,546	2,313,208	2,570,000	3,300,000
Connecticut	1895	219,165	1,307,381	1,865,948	2,197,264	3,172,706	1,195,125	3,640,963	3,200,948	4,004,225	5,018,820
Delaware	1903	14,000	31,000	31,000	21,600	429,734	90,803	511,628	512,000	321,600	943,377
Florida	1915			10,484	23,797	179,807	437,184	2,280,255	4,010,484	6,384,797	5,764,205
Georgia	1908				1,910	15,000	894,936	3,688,172	3,750,000	4,318,350	5,792,056
Idaho	1905		49,812	100,057	473,132	491,342	201,648	1,371,469	1,948,118	2,092,723	3,519,920
Illinois	1905		387,989	1,119,202	1,258,338	860,911	3,844,424	8,734,713	10,356,669	10,083,728	10,183,353
Indiana	1917				14,000		3,438,389	14,233,986	13,500,000	14,014,000	13,000,000
Iowa	1904		74,000	90,821	89,787	113,488	2,344,107	10,187,507	14,427,877	15,625,406	14,549,622
Kansas	1911		9,080	10,000	10,000	25,000	692,823	5,544,048	5,610,000	6,010,000	5,017,117
Kentucky[1]	1912		18,000	708,376	1,501,650	1,000,000	1,161,194	2,474,621	4,448,533	4,923,651	3,380,000
Louisiana	1910		161,186	184,533	182,295	182,295	345,452	1,777,572	3,458,643	3,540,976	3,540,976
Maine	1901	44,885	467,149	1,055,250	1,112,675	1,570,494	1,472,393	2,042,007	3,167,215	3,244,982	3,859,415
Maryland	1898		356,845	2,280,000	2,804,707	2,681,142	873,471	6,000,052	5,560,000	6,083,682	5,750,135
Massachusetts	1892	575,606	242,560	2,701,236	4,231,802	3,522,494	2,871,222	6,091,875	6,499,141	9,494,802	9,124,303
Michigan[1]	1905		657,264	982,939	1,704,359	1,704,359	1,816,504	9,261,998	10,082,939	11,190,153	10,673,153
Minnesota	1905		1,309,956	1,390,525	1,429,865	1,870,336	1,607,417	6,458,940	8,742,278	8,024,760	10,567,711
Mississippi	1915			6,500	6,500	10,000	339,669	3,960,377	3,256,500	3,256,500	760,000
Missouri	1907		277,253	482,860	367,913	704,400	1,570,801	5,513,049	7,982,860	7,374,933	7,154,400
Montana	1913		13,516	26,150	25,729	133,548	308,744	2,888,400	3,475,569	3,356,869	3,924,950
Nebraska	1911			110,000	9,500	201,202	494,886	1,796,278	4,500,000	4,603,400	3,855,828
Nevada	1911				36,796	75,328	46,876	245,014	275,000	336,796	474,770
New Hampshire	1903	44,000	491,520	414,669	589,254	651,594	872,606	1,590,464	2,045,410	2,238,705	2,004,685
New Jersey	1891	250,000	1,306,596	1,167,843	1,501,902	1,848,932	3,274,811	7,208,287	5,784,354	6,280,897	6,708,922
New Mexico	1909		115,732	385,684	280,578	527,072	35,458	556,399	828,952	845,867	1,314,192
New York[1]	1898	1,056,460	8,544,126	9,409,655	9,432,679	9,432,679	3,937,739	23,231,964	19,901,391	21,685,131	20,715,131
North Carolina[1]	1901		5,000	10,000	20,000	20,000	624,381	5,215,491	5,510,000	5,520,000	4,020,000
North Dakota	1909				28,638		456,130	2,402,384	2,711,295	2,867,979	3,208,000
Ohio	1904		1,855,338	2,885,071	2,835,649	83,000	4,776,318	14,334,246	12,992,625	12,017,104	14,499,834
Oklahoma	1911			300,000	286,922	4,670,270	447,320	2,112,681	3,625,000	3,722,355	3,131,532
Oregon	1913		10,697	165,662	711,000	1,046,893	649,718	5,310,467	5,955,662	5,711,000	6,830,276
Pennsylvania	1903	127,767	1,976,768	3,663,352	4,351,566	2,120,551	4,887,266	10,424,580	10,985,392	11,463,333	14,753,876
Rhode Island	1902	79,397		543,152	486,725	8,041,834	376,812	446,496	943,152	861,725	1,135,671
South Carolina	1917				27,161	745,674	334,082	1,024,480	1,250,000	1,277,161	1,676,239
South Dakota	1911				5,000	49,239	268,723	1,217,809	2,708,000	2,755,000	3,031,710
Tennessee	1915			200,000	231,500	30,473	629,141	2,370,560	4,600,000	2,481,500	2,978,000
Texas	1917				10,000	403,000	2,543,613	9,920,079	10,500,000	10,010,000	11,325,727
Utah	1909		157,732	179,400	120,200	295,567	158,286	803,071	1,855,160	1,893,129	2,770,491
Vermont	1898	127,381	458,456	632,800	578,883	1,546,843	567,397	1,023,941	1,607,800	1,680,489	1,606,075
Virginia	1906		523,578	542,524	695,171	778,075	687,751	3,224,529	3,691,249	4,136,779	3,708,352
Washington	1905		1,343,431	859,672	2,031,392	861,031	1,344,842	7,944,717	7,518,343	7,115,691	7,256,306
West Virginia	1909			10,967		2,922,436	587,870	2,483,747	5,510,967	8,200,000	5,056,454
Wisconsin	1911		1,482,379	950,000	1,050,888	171,581	1,924,026	9,880,240	10,570,764	9,886,554	9,284,175
Wyoming	1911				37,845	2,051,455	74,476	669,661	450,000	589,691	929,215
						67,582					
Total		2,549,850	24,220,850	40,969,001	47,290,796	66,351,478	59,427,180	240,263,784	272,634,424	279,915,332	286,098,113

[1] Data for 1918 not available; state expenditures shown in 1918 column are for the year 1917.

AVERAGE INCREASE SHRINKS.

The abnormal conditions during 1917 and 1918 had a very decided effect on road and bridge work. From 1904 to 1916 the average annual increase in the total rural road and bridge expenditures was about 10 per cent over and above those of each previous year. During the years 1917 and 1918, however, this increase was reduced to about 2½ per cent. The part which the several States pay in comparison with that of the local subdivisions, on the contrary, has continued to increase at a uniformly rapid rate. In 1904 eleven State highway departments expended a

important factor, while the employment of statute labor or working out of poll taxes is steadily decreasing from year to year. At the present time in more than one-half of our States the use of convict labor has definitely passed the experimental stage and has been established as a success.

CENTRALIZING CONTROL OF WORK.

One of the most notable features in the development of our road and bridge work is the increase in the amount of funds expended for road maintenance under the supervision and control of the several state highway departments. In 1914 the several State

highway departments directed the expenditure of $16,343,000 for maintenance. In 1917 this had increased to $27,649,000, while in 1918 it reached a total of $34,974,908. This increase is in part due to the heavier traffic and the rising prices of labor and materials, but more largely to the growing tendency to centralize the control of all our important highway work under competent State control and supervision.

While highway construction during the year 1918 was considerably curtailed, especially by the local subdivisions, extraordinary traffic development required a large amount of improvement and reconstruction of a quite substantial nature. The reason for these construction demands are readily apparent. At the present time approximately 6,000,000 motor vehicles, of which about 10 per cent are motor trucks and other commercial vehicles, are used on our public roads and streets. If each of these vehicles averaged only 5,000 miles a year, which is certainly a low estimate, the total traffic of all our motor vehicles will amount to approximately 30,000,000,000 vehicle miles per year. Furthermore, it is a well known fact that at least 75 per cent of the total traffic is concentrated on about 20 per cent of our rural public roads. Consequently, the reason why our roads are requiring so much greater expense and effort for adequate maintenance is readily apparent. This motor traffic, furthermore, has grown up almost entirely within the last 15 or 18 years and is entirely in addition to the horse-drawn traffic which, with the exception of pleasure vehicles, is probably as large as ever. At the present time the horse-drawn traffic on most of our roads forms less than 10 per cent of the total.

TRAFFIC TOO HEAVY FOR MANY ROADS.

The public roads of the United States at the present time have a total length of 2,478,552 miles, of which about 299,135 are improved with some form of surfacing. A large portion of this mileage, however, is comprised of sand-clay, gravel, or water-bound macadam, much of which is proving entirely inadequate for the present-day traffic and is rapidly deteriorating. During 1918 there was improved by the several State highway departments a total of 11,944 miles, of which about 7,000 consisted of grading, most of which was preparatory to later surfacing. In addition to this construction the several State highway departments also supervised the maintenance of 203,556 miles, most of which were main and trunk line highways.

The expenditures for 1918 by or under the various State highway departments are shown in Table 1 and the work accomplished is shown in Table 2. Table 3 shows the expenditures from purely State funds for the years 1904, 1914, 1916, 1917, and 1918, and also the total combined State and local expenditures for the same years. In Table 1 the columns under "administration" and "engineering" show a considerable variation in the percentage devoted to these purposes in each of the several States. These variations are probably due more to difference in bookkeeping and definition as to what items should be included under these heads than any other cause. There is a great need for common standards in regard to these items so that such expenditures may be fairly comparable as between the several States. This also applies to the term "reconstruction" and "maintenance." In some States practically all reconstruction work is classed under maintenance, while in others it is classed entirely under construction and in still others it is kept as a separate item and designated as reconstruction.

These compilations include no expenditures for road or street work by the War or Navy Departments and similar agencies in or at cantonments, training stations, or other places.

LARGEST COUNTY BOND ISSUE.

July 1 St. Louis County, Minn., by a vote of about 9 to 1, carried a proposition for the issuance of road bonds to the amount of $7,500,000. This is the largest sum ever voted or set aside at one time for road building by any county in the United States. The second largest was that of Dallas County, Tex., which voted a few weeks ago for $6,500,000.

The St. Louis County bonds are to be used for the construction of 270 miles of road under the Babcock plan. Under the act passed by the Minnesota Legislature last winter submitting to the people of the State at the regular election in 1920 a vote on a bond issue of $75,000,000 there is a provision that the money raised is to be used for building a system of State roads which are named in the law. The St. Louis County funds are for roads which will become a part of that system.

St. Louis is the great iron-ore mining county of the Lake Superior district, and has within its limits the largest and most valuable deposit of iron ore known. There are several cities and towns in the mining district of from 5,000 to 15,000 people. From Duluth, the county seat, on the south edge the county stretches to the north to the Canadian boundary, a distance of about 110 miles, and it has an average width of about 60 miles. The population in 1910 was 163,700 and is now about 200,000. One of the roads in the Babcock plan will traverse the county from Duluth to the northern boundary, passing through the Mesaba iron range. This road from Duluth to the mining region, a distance of 75 miles, is to be paved. No district in the county voted against the bond issue.

PRELIMINARY REPORT OF IMPACT TESTS OF AUTO TRUCKS ON ROADS

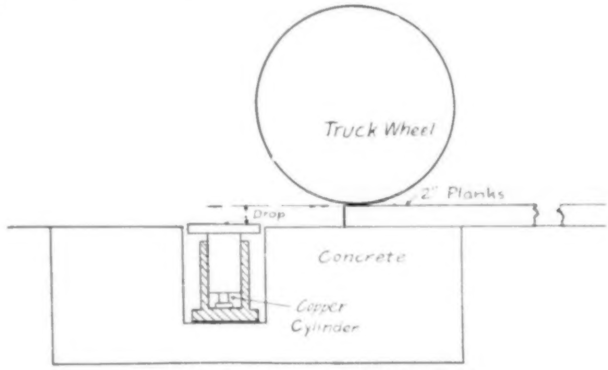
By E. B. SMITH, Sen. Asst. Testing Engineer, and J. T. PAULS, Highway Engineer.

REALIZING the destructive effect of heavily loaded auto trucks on highways and streets, and the demand for data on the design of road surfaces and foundations to withstand such heavy traffic, a series of experiments is being conducted by the Bureau of Public Roads at the Arlington Experimental Farm to determine the impact of auto trucks on roads.

The apparatus used in these experiments consists of a heavy steel cylinder in which is fitted a plunger 4 inches in diameter and 8 inches long, similar in construction to a hydraulic jack. A hole is left in the bottom of the cylinder in order to prevent air cushioning under the plunger. On the top or head of the plunger there is securely fastened a heavy steel plate, on which the impact of the truck wheel is received. This whole apparatus is supported rigidly in a concrete box placed in the road in such a position that the height of the steel plate on top of the plunger may be made just flush with the road surface. The height of the upper surface of the plate can be varied by proper steel disks placed under the plunger. In order that the front wheel may pass over and not touch the steel plate on the plunger, a steel bridge is used which is automatically tripped by the front wheel in passing over it. This releases a catch and allows a weighted lever to pull the bridge clear from the apparatus, thus leaving the steel plate exposed and ready to receive the impact of the rear wheel. By slight variations this bridge may be used to allow the impact of the front wheel to be received and then protect the plate from the impact of the rear wheel. The approach to this impact apparatus is made of 2-inch planking about 20 feet long and is so constructed that the height of the planks may be varied above the road surface to give various heights of drop, and also can be moved forward or backward to give the proper jumping distance from the jump-off point so that the wheel will strike the center of the plunger at all speeds.

RECORDING THE IMPACT VALUE.

For recording the impact value a copper cylinder one-half inch in diameter by one-half inch long is placed under the plunger of the jack. The impact received on the plunger is transmitted to the copper cylinder, where it produces a corresponding permanent deformation. The copper cylinders for this investigation are prepared from pure copper bars and are carefully machined to dimensions. They are then annealed by heating for 30 minutes at a uniform temperature of 650° C. in a bath consisting of a mixture of 20 per cent potassium nitrate and 80 per cent sodium nitrate, followed by cooling slowly in the air at room temperature. This treatment anneals the copper very uniformly. The finished cylinders are tested for uniformity in a universal testing machine under a pressure of 6,000 pounds total static load, five cylinders being taken from each heat-treated lot. Thus far the maximum variation from the mean deformation value has been only 1.3 per cent, and this is less than other experimental errors.



APPARATUS USED IN MAKING TESTS.

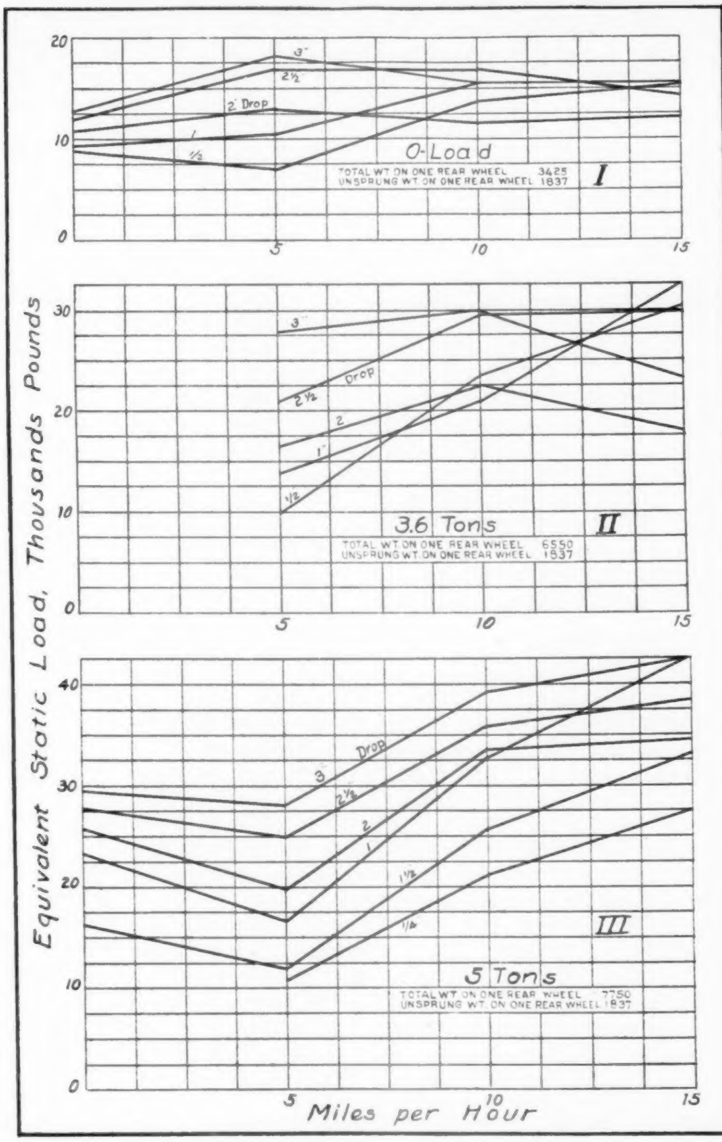
A 3-ton U. S. A class B truck with solid rubber tires was used for these experiments. The weight of the truck empty is 11,400 pounds; weight on front wheels, 4,550 pounds; weight on rear wheels, 6,850 pounds; weight of unsprung rear parts, 3,675 pounds. Deflection of rear spring under weight of body alone is 0.74 inch. Weight on rear wheels when loaded with 7,200 pounds (3.6 tons) gravel is 13,100 pounds; deflection of rear spring, due to load and body, 2.62 inches. Weight on rear wheels when loaded with 10,000 pounds (5 tons) gravel is 15,500 pounds; deflection of rear spring, due to load and body, 3.62 inches. Diameter of rear wheels is 40 inches, each fitted with two solid rubber tires, and each tire is 6 inches wide at the base next to the rim. Impact values were obtained only for the rear wheel, as it was the object to obtain values of the maximum impact of the truck. Rear springs were 57½ inches long, 4 inches wide, 6½ inches deep, with 17 leaves.

THE TEST CONDITIONS.

The impact condition under which these tests were conducted was the simple falling of the truck wheel from one level to another at different speeds

of the truck; the height of drop varying from ¼ to 3 inches. Other conditions of impact will be investigated later. The magnitude of the impact is dependent upon: (1) height of drop, (2) weight of truck and load, (3) kind and condition of tires, (4) characteristics of springs, and (5) speed of truck. Under these conditions, a series of tests were run, and the results are shown on the accompanying curves.

The impact, while measured by the shortening or compression of the copper cylinders, is shown in equivalent static load. That is, for each compression value of the copper the static load has been determined which would produce the same compression. All the curves are thus shown with the equivalent static load as ordinates. This may not be a perfect comparison of impact loads, as loads applied with impact will probably produce a much localized shattering effect which does not result from the application of an equivalent static load. For this reason, the present methods of comparing impacts by their equivalent static loads must be considered as tentative and subject to possible revision as the tests proceed.



ELEMENTS OF DESTRUCTIVE EFFECT.

The tests thus far give only the relative impact values, and do not attempt to demonstrate the destructive effect of these impacts. The destructive effect depends upon the road surface, the type of construction, and the foundation, and to arrive at the destructive effect of these impact forces, it is proposed in another series of experiments to subject certain road surfaces to these same impacts repeatedly until failure occurs. Machinery and apparatus for this purpose are now under construction.

The results as shown in curves I, II, and III indicate a general tendency of increased impact toward the higher speeds, although the increment of increase is less as the speed increases. The relatively

[Continued in next column.]

high impact values at zero speed, as shown in curve III, are explained by the fact that the results were obtained by dropping the wheel vertically upon the impact plunger, which resulted in the copper cylinder receiving, first, the impact, or kick of the spring, then an additional load an instant later from the falling of the truck body and load. Curves IV, V, and VI show the same data plotted with height of drop as abscissæ. These curves indicate a general increase of impact with the increase of height of drop.

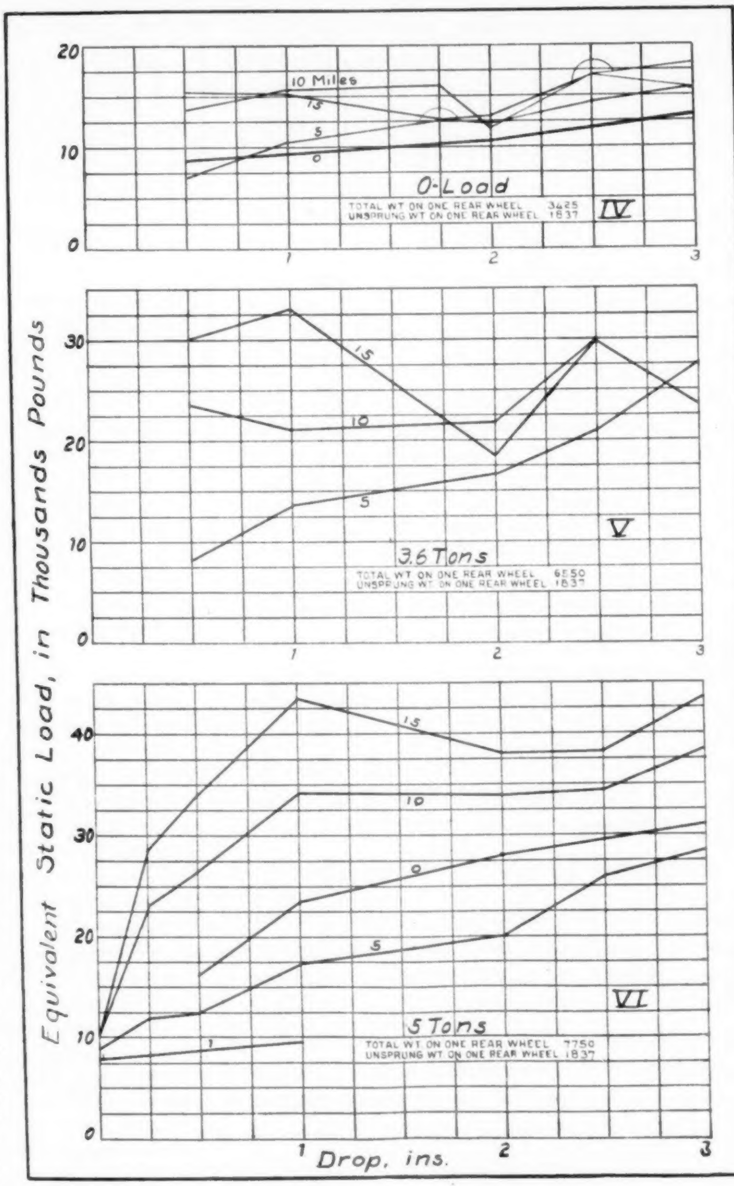
SPRINGS HAVE GREAT INFLUENCE.

In conducting these experiments it was soon discovered that the action of the truck springs had a great influence on the impact results. When the wheel leaves the jump-off point the spring snaps open and produces a greater downward acceleration of the unsprung parts than that due to the action of

BONDS BRING PREMIUM.

Twenty-three bids were made for the $12,000,000 of Pennsylvania State road bonds, the first allotment of the $60,000,000 in bonds voted last fall. The issue is to be put out in blocks of $2,000,000 at 4½ per cent, maturing in 5, 10, 15, 20, 25, and 30 years. The highest bid was $103.52.

gravity alone. If the compression of the spring is e and the height of the drop or jump-off point is d, then within the time of one vibration of the spring, the magnitude of the impact at the landing point will depend upon whether $d<e$, or $d=e$, or $d>e$. If the period of vibration is such that the spring has acquired its maximum acceleration, and at this instant also lands at the point of impact on the road surface, the impact value will be a maximum. The impact value will be a minimum when conditions are such that the spring is returning to its closed position and is at the point of maximum acceleration in this direction as the impact occurs. This explains why the impact values, as shown in the curves, do not consistently increase with the height of drop. The static loads equivalent to the impact values under the higher loads and drops are as much as five times larger than the total dead load.



POWER INCREASES IMPACT.

It was also noticed during these tests that the impact was appreciably affected by the conditions of power on or off. That is, if the impact occurred when coasting it was less than when the power was being applied to the rear wheels. This difference amounted in some cases to as much as 30 per cent.

These results are presented at this time only for the purpose of showing the general tendency of impact values. It is the intention to enlarge upon this investigation to determine the relative effects of kinds of tires, loads, speeds, spring characteristics, and character of road obstructions and defects which produce impact values, and attempt to arrive at some definite conclusions as to the destructive effect of truck loads on different types of roads. It is hoped that this will ultimately result in definite road design data, and also lead to the establishment of rules and laws for the allowable loads and speeds of auto trucks, and possibly furnish an equitable basis for license fees. Special apparatus is being designed to obtain autographic records of these tests.

$2,000,000 FOR ROADS.

A bond election is proposed for this fall in Emmet County, Mich., for from $350,000 to $500,000 for highway construction. This amount is to be part of a program which will call for a total expenditure of about $2,000,000.

FOR HARD SURFACE ROADS.

Iowa is moving for hard surfaced highways. Elections have been held in a number of counties since June 1 on the question of hard surfacing roads. Fourteen counties voted favorably and in four counties the proposition was defeated. In addition to voting for hard surfaced roads these counties voted for bond issues to build the roads faster than current appropriations will permit: Woodbury County, $3,000,000; Polk and Scott Counties, $2,000,000 each; Black Hawk and O'Brien Counties, $1,500,000 each, and Cerro Gordo, $750,000. Palo Alto County, while voting in favor of hard surfaced roads, defeated a proposed bond issue of $750,000.

A number of other counties will hold elections in regard to hard surfacing and four or five on proposed bond issues between this time and November.

TESTING AGGREGATES IN THE FIELD

By F. H. JACKSON, Assistant Testing Engineer.

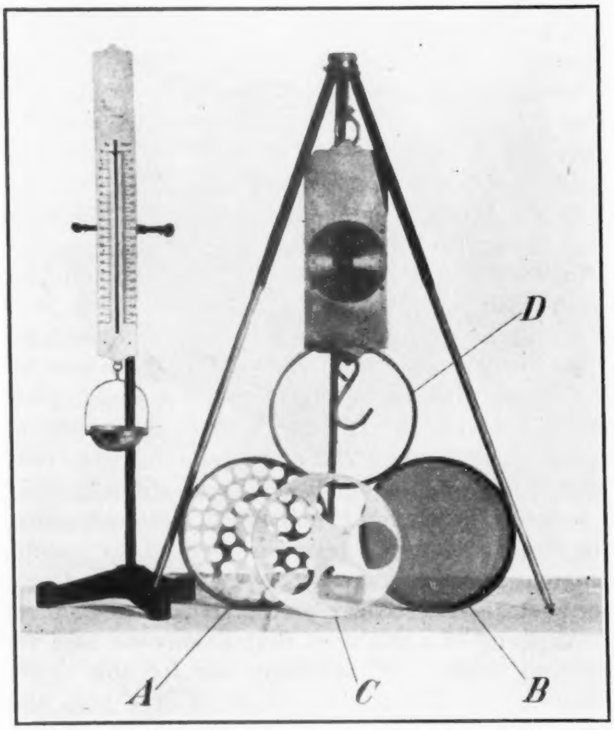
A FACTOR which probably tends more than any other to discourage adequate control testing of highway materials is the time usually required to send samples to a laboratory for test purposes. Even under the most favorable conditions several days may elapse before a report can be secured, during which time the lot of material represented by the sample must be held. Conditions frequently are such that an engineer or inspector must decide at once upon the arrival of a shipment whether to accept or reject it, so that, unless he is provided with equipment for making tests himself, he must base his decision solely on visual inspection.

Although an inspector ordinarily may be able to reject a consignment without question, instances often arise when even the most expert may be in doubt. This is especially true in connection with determinations of the grading or size of aggregates. These materials always are subject to variations in size due to inefficiency in plant screening and other causes and yet may be intended for use in construction requiring uniformly graded aggregates. An examination, of course, may be made in such cases with the ordinary laboratory equipment. Such equipment, however, is bulky and difficult to move from place to place, and therefore is not adapted to field use, so that up to the present time there has been little or no systematic control testing in the field. The obvious solution is to supply a field equipment which will accomplish the same purpose and still be compact, light, and capable of withstanding a certain amount of rough usage. A description of such an outfit which has been developed recently by the Bureau of Public Roads, together with suggested methods for its use, follows:

DESCRIPTION OF APPARATUS.

The field equipment so far developed consists of the following units:

1 set interchangeable stone screens, with screen plates having perforations 3, $2\frac{1}{2}$, 2, $1\frac{1}{2}$, 1, $\frac{3}{4}$, $\frac{1}{2}$, and $\frac{1}{4}$ inch in diameter.
1 set interchangeable sand sieves, of 10, 20, 30, 40, 50, 80, 100, and 200 mesh.
1 circular spring scale having a capacity of 30 pounds and sensitive to 0.1 pound.
1 straight spring balance having a capacity of 200 grams and sensitive to 1 gram.
1 demountable cubic foot box.
1 ordinary camera-folding tripod.
1 250 c. c. graduate.
1 strip of screen wire about 22 inches in length and 5 inches high.
2 canvas bags about 18 by 18 inches in size.



APPARATUS FOR MAKING FIELD ANALYSIS OF AGGREGATES.

The interchangeable screens used in this equipment were developed in the course of a field study of stone and slag crushing practice which was undertaken recently by the Bureau of Public Roads. They have been used for obtaining mechanical analyses of coarse aggregates, substantially as described below, by engineers of the Bureau throughout two field seasons and have given uniformly satisfactory results. The set consists of a number of perforated screen plates 8 inches in diameter, and two brass rings, one of which is provided with a narrow shoulder on the inside upon which a screen plate may be placed. The two rings are then firmly clamped together so that the screen plate is held rigidly between them. This forms a screen of the same size and shape as the ordinary laboratory type. When not in use all of the plates may be clamped together in the ring so that the whole set takes up no more room than a single laboratory screen.

The circular spring scale is equipped with a loose pointer for obtaining the net weight of the material being examined. It is graduated in 0.1-pound divisions and one complete revolution of the pointer equals 10 pounds. The scale has a total capacity of 30 pounds or 3 revolutions of the pointer.

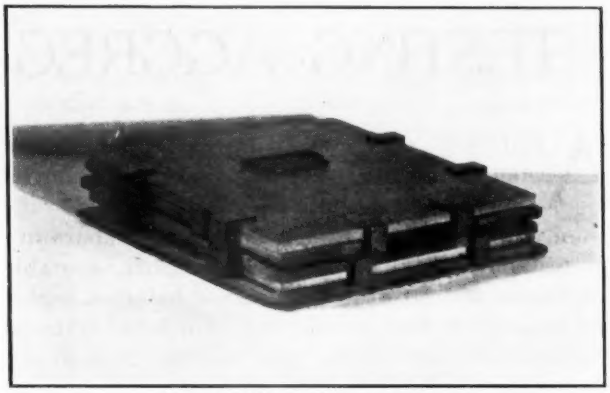
The sand sieves are of the same general type as the screens, the various sieve plates fitting into the

brass rings in the same manner. Thus, a sieve of any desired mesh may be made up by simply inserting the proper sieve plate in the lower ring and clamping it down by means of the upper ring. A soft rubber washer is placed over each sieve plate so that the upper ring will clamp down on it, thus making a dustproof joint. The straight spring balance is of a special type graduated on one side from 0 to 200 grams by 1 gram divisions and on the other side from 0 to 100 per cent by 1 per cent divisions. It is used in making mechanical analyses of fine aggregates. An aluminum cup is provided large enough to hold a 200-gram sand sample.

In the illustration of this equipment the circular screen scale is supported by the tripod in the way it would be in practice. A screen plate inserted in the lower ring is shown at A, a sieve plate inserted in the ring is shown at B, C shows a screen plate before insertion in the ring, and D the upper, or clamping, ring. The 250 c. c. graduate is the only piece of glass in the outfit and is needed only when it is desired to make volumetric silt determinations. The circular loop of screen wire is used for making apparent specific gravity determinations of coarse aggregates. The object of the strip is to increase the capacity of a screen so that it may be used for weighing samples of sufficient size for this determination. It is rolled in the form of a loop and placed inside of the screen ring which in turn is suspended from the spring scales by means of three light wires.

The demountable cubic foot box is used for determining weight per cubic foot of crushed slag and other coarse aggregates. It is made of five pieces of light strong wood $\frac{3}{8}$ inch thick, the bottom $12\frac{3}{4}$ by $12\frac{3}{4}$ inches, two sides 12 by $12\frac{3}{4}$ inches and two sides 12 by 12 inches. The four sides are first slipped into place and held by the notched brass angles shown in the illustration. The bottom is then slid into place in the angles provided on three of the sides. Field experience with this measure has suggested that the wooden bottom be protected on the outside by a sheet of thin metal. This would materially increase the life of the apparatus. In making sieve analyses this box is very handy for catching the fines. When collapsed the box consumes little more space than the actual volume of the material. When made of poplar the total weight is 7 pounds. Oak, while harder, would increase the weight a pound or so.

The total outfit described above weighs approximately 18 pounds. The apparatus making screen and sieve analyses weighs approximately 10 pounds and may be packed in a space measuring 17 by 8 by 6 inches.



CUBIC-FOOT BOX COLLAPSED.

SUGGESTED METHODS FOR SAMPLING.

The importance of the proper sampling of materials in connection with the field testing of aggregates can not be overemphasized. It is the one branch of testing work to which the least attention is paid, and yet, if sampling has not been done properly, the most carefully made tests are worse than valueless. For this reason, unless the inspector is prepared to spend the necessary amount of time in taking samples, he should not attempt to make any tests whatever.

There are two points which must be borne in mind when sampling crushed stone and gravel aggregate. In the first place, the sample must be representative of the entire quantity being examined; and in the second place it must be large enough so that the largest individual piece will in no case weigh more than 2 per cent of the weight of the entire sample. When sampling crushed stone or gravel from cars or trucks a sufficient quantity should be taken from each end as well as from the top and bottom of the car to insure an average of the entire shipment. A shovelful taken from the top is not sufficient. A composite sample should then be prepared by thorough mixing after which it should be reduced by quartering until a sample has been secured weighing at least 50 times the weight of the largest fragment present.

In sampling from stock piles on the job, at the plant, or from bins the same precautions as noted above should be observed. Sampling from cars or trucks before or after delivery is much to be preferred to sampling from bins, because of the greater ease in obtaining average samples.

In sampling sand one of the principal precautions to be observed is to see that the sample taken contains an average amount of the loam or clay present in the shipment. Samples should be obtained whenever possible from damp sand, owing to the difficulty of obtaining a truly representative grading

when the sand grains are dry. A composite sample weighing 10 pounds made up of samples from each end and from the top and bottom of the car should be taken.

USE OF APPARATUS.

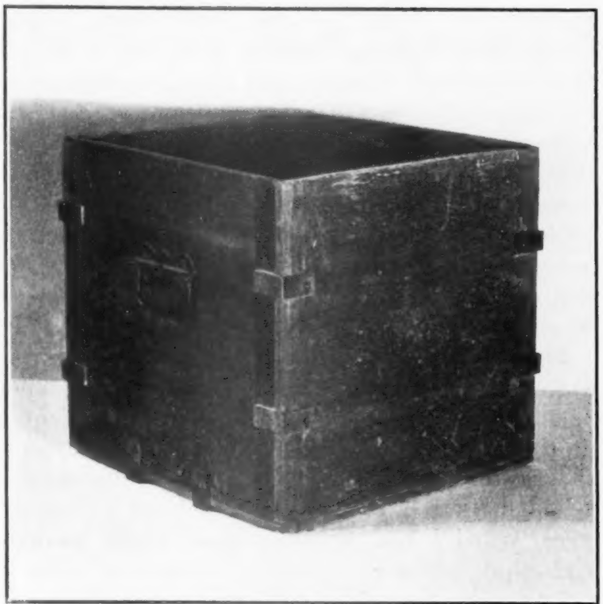
In making a mechanical analysis of a crushed stone aggregate with this apparatus a number of points should be noted. The tripod should be set up and the circular spring scale suspended from it as close as possible to the material being examined. The shipment should then be sampled in accordance with the given suggestions. The whole sample thus prepared may then be passed through the various screens and the percentage by weight retained on each calculated; or, in the case of mixed aggregates graded up to 2 or 3 inches in size, a number of determinations may be made and the results averaged. It has been found convenient to make the original weight of each sample 10 pounds or some multiple of 10 pounds. Inasmuch as the dial of the scale is graduated by one-tenth pound divisions, the various weights may then be read either as percentages direct or converted into percentages by simple calculation.

In making sieve analyses of sand or stone screenings less than one-quarter inch in size the straight spring balance should be used. A 100 or 200 gram sample may be dried in any convenient manner and a mechanical analysis made in the ordinary way, using the interchangeable sieve plates. If a 200-gram sample is used the percentage of material retained on each sieve may be read direct from the scale. A mechanical analysis made in this manner on materials containing an appreciable amount of clay or loam, especially if it occurs as a coating on the sand grains, will not be absolutely comparable with a laboratory analysis. It will give, however, a fair indication of the grading of the material sufficient in most cases for control work.

VOLUMETRIC SILT DETERMINATIONS.

Volumetric silt determinations should be made on all sand used in concrete work. Inasmuch as there is no definite relation between the silt content as determined by weight and by volume, it is recommended that the laboratory making the preliminary tests on the sand report the silt content in both ways. This will make it possible for the inspector to compare his results with the specification requirements which are nearly always written on the weight basis. The following suggested methods for making a volumetric silt determination may be used: A 250 c. c. glass graduate is filled to the 100 c. c. mark with water. Sand is then poured in up to the 100 c. c. mark after which the graduate is thoroughly shaken. After allowing the sand to settle until the water is approximately clear the volume of silt may be read and its percentage calculated from the total volume of the sand in the graduate. The line of demarkation between the silt and the sand is usually very distinct.

A quick determination in the field of the apparent specific gravity of an aggregate is sometimes of value, especially in the case of very heavy or very light materials. It may be made easily and fairly accurately with the equipment described. A screen fitted with a loop of screen wire and suspended from the large spring scale is filled with the aggregate to be examined and its weight recorded. A 10-pound sample may be used conveniently. The entire container, together with the sample, is then immersed in water and immediately reweighed. The apparent specific gravity may be computed from the loss of weight. An ordinary bucket of water may be used for immersing the sample. Numerous tests made with his apparatus indicate that results accurate to at least the first decimal place may be assumed.



CUBIC-FOOT BOX SET UP.

WEIGHT PER CUBIC FOOT DETERMINATION.

The determination of the weight per cubic foot is of value principally in the case of slag. The demountable box previously described affords a convenient way of making this determination on the job. The method so far used is to shake the material to refusal in layers of 3 inches each, striking the box upon the ground by rocking it back and forth twenty times after each layer has been deposited.

The systematic use of a field equipment similar to that described should prove of value both in the plant and field inspection of highway materials. A number of uses of the various units comprising the equipment will suggest themselves to engineers. For instance, the interchangeable sieves and small spring balance may be very conveniently used in sheet asphalt control work. In proportioning aggregates for various types of bituminous concrete roads, the outfit should prove of value. In fact, it may be used advantageously in any work in which a rapid determination of the size or weight of aggregate is desired.

Detailed information regarding the manufacture and use of any of the equipment described above will be given upon application to the Bureau of Public Roads.

IN TWO GEORGIA COUNTIES.

Elections will be held in the near future in Muscogee and DeKalb Counties, Ga., on proposed highway bond issues. In the latter the proposition is for an issue of $750,000 and in the former for one of $740,000.

CALIFORNIA BOND ISSUE.

California voted by about 7 to 1, July 1, in favor of the proposed constitutional amendment providing for a bond issue of $40,000,000 to complete the State highway system. In addition to this $40,000,000 there is available for the system $3,000,000 from the appropriation of 1915-16, about $6,000,000 provided by counties for laterals from the burden of which this amendment now relieves them, and $8,000,000 in Federal aid, making a total of $51,000,000 to be expended on the State system within the next few years.

The State voted in 1910 for a bond issue of $18,000,000 for two trunk roads, covering about 3,000 miles. This amount was not sufficient to do the work, and in 1916 $12,000,000 additional for the State system and $3,000,000 as one-third of $9,000,000 for laterals to be completed by counties were voted. The amount now made available and that already expended makes a total of $81,000,000 provided for the State highway system in 10 years. In addition to this amount counties have raised many million dollars for other roads. The amount voted by counties this year will be almost as great, in the aggregate, as the new State bond issue.

FOR IDAHO ROADS.

Ada County, Idaho, will vote on a road bond issue of $1,000,000. If the proposition carries the funds are to be used for nothing but hard-surfaced roads. It is believed this amount will be sufficient to complete the good-roads system throughout the county. Fremont County, that State, has voted in favor of a bond issue of $400,000. Three additional road districts in Latah County have voted $420,000, bringing the total amount voted in that county to $1,125,000. Other proposed bond elections are in Washington County for $200,000 and in the Nampa road district for $500,000. Teton County has voted on an issue of $100,000.

BOND ROADS IN MONTANA.

Five Montana counties have this year voted for issuing bonds for road building. They are: Gallatin, $400,000; Yellowstone, $75,000; Meagher, $150,000; Sweetgrass, $100,000; and Park, $150,000. In September special elections will be held in 31 counties. If all should cast a favorable vote, there will be a total of $6,688,000 in highway bonds voted by Montana counties this year. The largest proposed issue is that of Fergus County, $700,000. Cascade County will vote on an issue of $500,000; Custer, on one of $350,000; Fallon, $275,000; Yellowstone, Missoula, and Silver Bow on $250,000. Other amounts run from $35,000 to $200,000.

A YEAR'S ROAD RECORD.

The State highway department of Pennsylvania is making a great record this year in pushing highway construction. The State highway commissioner has advertised for bids to be opened August 5 for the construction of 60½ miles of roads located in various parts of the State and will soon advertise for bids for 74.7 additional miles. These will bring the total mileage of roads for which contracts have been let or for which they have been advertised this season up to 675.7 miles. This is said to be the best known record in such work, but the commissioner will continue to let contracts throughout August and September.

Contracts let up to July 24 include 452.25 miles of the primary highway system, for $16,020,924.70, 10.89 miles of the secondary road system at a cost of $468,500.29, and 7.33 miles of State-aid roads not on the State highway system at a cost of $259,810. The total contracts awarded call for 470.45 miles at the low-bid-price of $16,749,235.34. A recent inspection showed that on 59 contracts the construction on 52 was up to or above par in the progress made by the contractor.

On August 18 bids will be opened for the construction of 66 concrete bridges.

$2,500,000 BONDS FOR PAVING.

Woodbury County, Iowa, of which Sioux City is the seat, voted July 7 by about 4 to 1, in favor of a highway bond issue of $2,500,000. Only two townships voted against the issue, while in Sioux City the vote was nearly 13 to 1. The county has 125 miles in its primary system of roads which has been approved by the State highway commission. The larger part of this system has been graded and drained, and is practically ready for the paving to be laid from the proceeds of this bond issue. Plans have been made so the work can start with practically no delay.

SPOKANE VOTES $3,250,000.

By a vote of 6,984 to 3,366 Spokane County, Wash., approved the proposed issue of road bonds to the amount of $3,250,000. It is estimated that 300 miles of new road will be built. The first $450,000 of the bonds will probably be sold about January 1, so that work on the system can start in the spring. The projects will be grouped. A construction engineer will be employed, and he and the county board of supervisors will decide upon the most important improvements and the order of construction. The townships must bind themselves to furnish 15 per cent of the cost of a road.

ROAD BUILDING IN THE SOUTHWEST

By M. O. ELDRIDGE, Assistant in Road Economics.

THE Federal aid road act has had the effect of stimulating road building throughout the length and breadth of the country. There is no section of the country, however, where road building is now being carried on with more vigor, if considered from the standpoint of wealth and population, than in the semiarid and irrigated regions of the great Southwest. This statement is based on observations made on a recent trip of inspection over a proposed link in a southern transcontinental highway extending from El Paso, Tex., to San Diego, Calif. This road is known as the Bankhead Highway and extends from Washington through the Southern States to the Pacific coast, the road having already been designated as far west as El Paso.

Unusual road activity in the Southwest is indicated by the fact that the State of Texas is planning to issue $75,000,000 of road improvement bonds with which to meet Federal aid and cooperate with the counties in building a system of State highways. Between January 1 and June 1, 1919, Texas counties voted $63,667,000 of road improvement bonds. California voted a $40,000,000 bond issue with which to complete its State system, that State having already voted and expended $33,000,000 for the same purpose. Numerous counties in Texas, New Mexico, Arizona, and California have provided large sums of money with which to meet State and Federal assistance. Maricopa County, Ariz., for instance, recently voted $4,000,000 with which to complete a system of country roads, and Fresno County, Calif., $4,800,000.

INFLUENCE OF FEDERAL AID.

The influence of the Federal aid road act is further shown throughout this section of the country by the fact that States and counties, almost without exception, are providing themselves with competent engineering help under whose direction these large sums of money will be expended. There is every reason to believe that within the next few years the more important roads in this whole region will be improved, as well as the missing links on the great transcontinental highway above referred to, among which should be mentioned the road across the Monahan sands of Ward County, Tex., the almost impassable sections of road across the silt flats between Phoenix and Yuma, and the sand hills between Yuma and El Centro in California.

El Paso County, Tex., has already completed her section of the transcontinental highway. From El Paso to the Hudspeth County line on the east the road is composed of bituminous concrete. It is about 18 feet wide and is planted on both sides with cottonwoods which make the road very picturesque and pleasing to those who use it. From El Paso on north to the New Mexico line the road is paved to a width of about 18 feet with concrete. These two sections of road rank with the best pieces of road on the entire route from the Atlantic to the Pacific.

The roads through New Mexico consist largely of natural roads over a desert country through the desert growth of chaparral, greasewood, and mesquite. The soil for the most part contains sand or gravel and the roads are fair except in the low places where they cross adobe flats. Even in the adobe flats the roads, although rough, are fairly good for the light traffic to which they are subjected except in the rainy season. On several sections of the route in New Mexico, notably near Deming and Las Cruces, the roads have been graded and drained, drainage structures provided, and the roads surfaced with gravel. Many miles of these roads appear to be entirely satisfactory for present traffic needs.

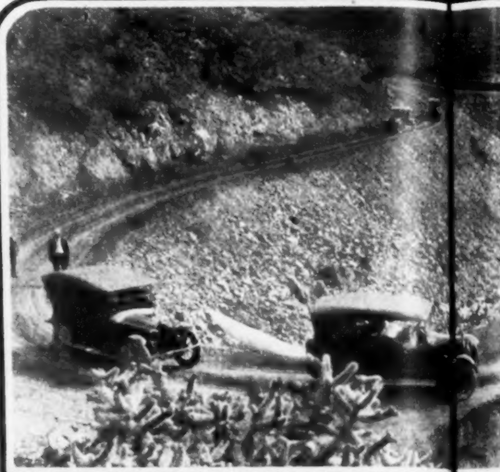
CONVICTS BUILD A ROAD.

Under the direction of the County Road Commission, Cochise County, Ariz., is expending about $1,000,000 on the improvement of its most important roads with gravel and concrete. Between Douglas and Bisbee a concrete road is now under construction. Between Bisbee and Tombstone a road was completed last year with convict labor by the State Highway Department of Arizona, which is now in first class condition. This is a splendid piece of mountain road construction. The road is surfaced with disintegrated granite and is kept in splendid condition by dragging. The county road between Douglas and Benson is now being completed by the county road commission of Cochise County.

One of the best and cheapest pieces of gravel road construction found on the various routes in Arizona was between Vail and Tucson, in Pima County. This road cost less than $1,000 a mile, due to the fact that the mesa over which it is constructed is composed of a gravel formation. The work of construction consisted principally in clearing away the greasewood, cactus, and other desert growth, paving the dips, grading the road surface, and providing proper ditches.

To the casual observer ditches, culverts, and bridges would not be needed in the arid regions of the Southwest, but it is found that during the rainy season the water comes down in torrents and that when the friable soil is thoroughly saturated drainage structures are just as necessary as in the Eastern States. In fact, one of the principal problems of the road building in the Southwest consists in protecting

MOUNTAIN ROAD BETWEEN BISBEE AND TOMBSTONE SURFACED WITH DISINTEGRATED GRANITE.

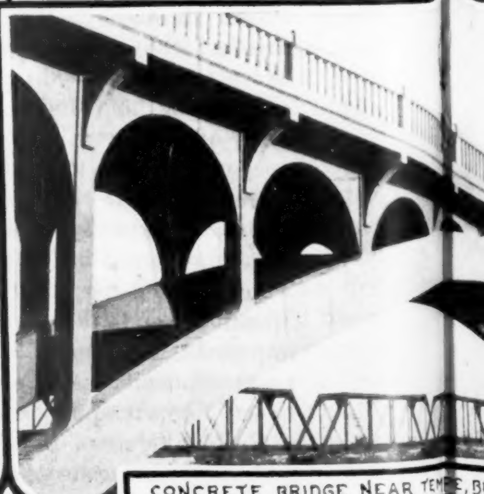


STATE HIGHWAY BETWEEN SOLOMO

PLANK ROAD ON THE DESERT BETWEEN YUMA AND HOLTVILLE.

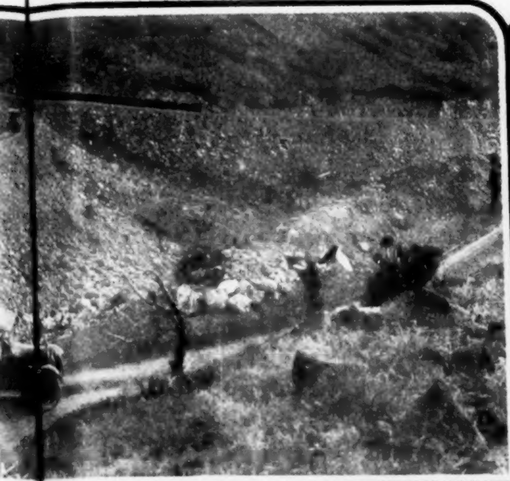
TYPICAL GILA VALLEY ROAD NEAR SOLOMONVILLE

TYPICAL ROAD ALONG THE GILA RIVER NEAR AGUA CALIENTE.



CONCRETE BRIDGE NEAR TEMPE, B

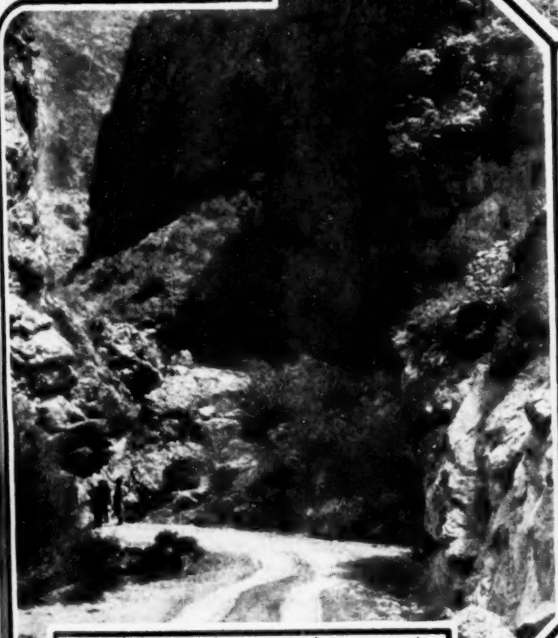
ON THE HIGHWAYS OF THE



...WEEN SOLOMONVILLE AND CLIFTON.

MOUNTAIN ROAD BETWEEN BISBEE AND TOMBSTONE SURFACED WITH DISINTEGRATED GRANITE.

...ILLE



ON THE ROAD BETWEEN TEMP AND ROOSEVELT DAM, APACHE TRAIL. FOOT OF FISH CREEK HILL.

CONCRETE ROAD NORTH OF EL PASO NEAR NEW MEXICO LINE.

...AR TEMPE, BUILT WITH STATE PRISONERS.

STUCK IN DESERT SANDS BETWEEN YUMA AND HOLTVILLE.

...S OF THE GREAT SOUTHWEST.

the road from erosion, due to the quick rise of water in the stream beds during the rainy season, or to the flow of water down the naked slopes of mountains and mesas.

AVOIDING USE OF CULVERTS.

Instead of constructing culverts and bridges in the usual way the practice has developed during the few years in the Southwest of paving or providing curbs on both sides of improved roads where the roads cross dry stream beds locally known as "arroyas." These paved fords or dips permit the flood waters to flow across the road surface without causing erosion. It is found that the construction of these dips is much less expensive than the construction of culverts and bridges and that they are just as satisfactory, except where they cross the the larger stream beds.

Another problem which confronts the road builders of the arid regions is the building of roads across the adobe flats and where the soil is composed of fine silt loam. If the roads across these flats are used much in dry weather, the soil pulverizes into dust, and the roads become full of dust holes in which vehicles often sink to the axles. In the rainy season these same places develop into mudholes which render the road almost impassable. The road between Phoenix and Yuma, along the Gila River near Agua Caliente, contains many places similar to those described.

One of the most picturesque highways in Arizona is the road known as "The Roosevelt Road," or "The Apache Trail," which extends from Phoenix to Globe via Roosevelt Dam, thence to Clifton through Solomonville. The section of this road from Masa to Roosevelt was built by the United States Government as a wagon road over which to haul cement to the dam site before the cement plant was constructed. It is not at present well suited to automobile or tourist traffic as many of the grades are rough, narrow, and dangerous and the surface is poorly maintained.

SAND BURIES DESERT ROAD.

From Roosevelt to Globe the road is at present all that could be desired. Through the Gila Valley, from Globe to Solomonville, and on toward Clifton, there are many stretches of excellent gravel road. There is also a good section of gravel road over the mountain into Clifton built by convict labor under the direction of the State highway department. Aside from a few adverse grades this is a fine piece of mountain road building. Between Clifton and Lordsburg, N. Mex., the road extends across several mesas through a beautiful rolling country covered with typical desert growth. The road is composed largely of gravelly soil.

To the ordinary road traveler the trip from Yuma, Ariz., to Holtville, Calif., across the desert sands and sand dunes involves many hazards. These dunes vary in height from 10 to 20 feet, and are constantly shifting. A road built over or through them would be covered with sand within a few days, sometimes within a few hours. A few years ago several miles of plank road were built across these dunes, but several workmen and teams have to be constantly employed in removing the sand in order that the road may remain open. These sands could be avoided by building the road around them to the north, but such a road between Yuma and Holtville would be about 50 miles longer than directly across the sands.

It is understood that the State of California has provided that this road is to be improved, with funds derived from the proposed bond issue, thus connecting Yuma with the coast at San Diego by a hard-surfaced road. It is also understood that the plan proposed for crossing the sands will be to build a bridge from 20 to 30 feet high over the sands, open underneath so as to permit the circulation of air and sand.

IRRIGATING EARTH ROADS.

The natural earth roads in the Imperial Valley in southern California become very dusty in the dry season and very heavy in the wet season if subjected to heavy or fast traffic. During the past few years a practice has grown up in the valley of irrigating the roads. For this purpose the road is laid out in sufficient width for two separate and distinct driveways with a ridge of earth between. Instead of crowning the road as in a humid country the surface is made to slope slightly toward the center and is slightly below the surface of the irrigation ditches which usually parallel the road on both sides. About every two weeks during the dry season one side of the road is irrigated. When the surface begins to dry it is dragged. During this process the other side of the road is being used by traffic. As soon as the irrigated section is dried out sufficiently, traffic is turned on and the other side of the road is then irrigated. This method of maintenance produces a comparatively hard and dustless surface and has proven very satisfactory. The roads are usually planted on both sides with poplars, cottonwood, and eucalyptus and are very beautiful and pleasant to rive over.

Between Holtville and San Diego through Imperial and San Diego Counties the State of California has either completed or has arranged for the completion of a paved highway 16 to 18 feet in width. The scenery along this road through the coast range mountains is particularly beautiful. The State road through El Cajon Valley in San Diego County deserves special mention. The road is paved with a durable surface to a width of about 18 feet and excellent taste has been displayed in the planning and planting of the roadsides.

JUNE A RECORD-BREAKING MONTH FOR FEDERAL-AID ALLOTMENTS

IN June the record of Federal-aid statements approved surpassed that of all previous months in the numbers of projects, the mileage involved, the estimated cost of the roads to be built and the amount of Federal aid allowed. This is also true in regard to the record of the project statements for which agreements were signed by the Secretary of Agriculture. Since early in the year there has been a steady increase each month in the Federal-aid business in the Bureau of Public Roads. States in all sections of the country are filing their projects and receiving allotments. The road-building era is in full swing, and it would seem that the end is not yet. All indications point to yet greater records in the months immediately to come.

The table of Federal-aid projects considered during June in this issue of Public Roads lists 239 projects. New statements approved were 133, while there were revisions of 4 statements previously approved. Sixty agreements were executed, 41 previously executed were modified and 1 was cancelled, the road being provided for in a modification of another project.

The statements approved during the month were for 1,426.84 miles of road, estimated to cost $25,611,314.99, with a Federal-aid allowance of $11,725,500.61. These are increases over the May figures of 663.897 miles, $10,407,436.93 in the estimated cost and $5,297,082.82 in the amount of Federal aid.

Agreements signed by the Secretary of Agriculture called for Federal aid amounting to $4,376,743.98, with an estimated cost of $7,566,089.32.

The June statements approved bring the total amount of Federal aid applied for up to $54,654,984.44, almost $5,000,000 in excess of the amount which would have been available up to the close of the fiscal year 1920 under the original Federal aid law.

BIG ILLINOIS PROJECTS.

Two new projects from Illinois set a new record. No. 8 for 86 miles of road, is estimated to cost $2,321,650.00, and No. 9 for 150 miles of road, is estimated to cost $4,463,511.60. Although project No. 8 does not break previous records for length of a single project, it does break the previous record for total cost, and project No. 9 breaks the previous records both for length and cost.

Project No. 8 involving the construction of the East St. Louis-Springfield Highway in southwest Illinois, begins at the north city limits of Granite City in Madison County, and extends northward through the counties of Madison and Macoupin to the south city limits of Springfield in Sangamon County. It is an important link in the $60,000,000 State highway system and a portion of the main highway connecting St. Louis and Chicago. The general topography of the country is level or slightly rolling and is well developed farming land. The present road surface is unimproved earth which becomes nearly impassable at certain seasons of the year. During the winter months there is practically no through traffic. During the summer months the average daily through traffic is approximately 5 trucks and 100 passenger motor vehicles. Local traffic will vary according to the proximity of the section to the different towns along the project, but for the entire road the average daily is approximately 30 trucks, 200 passenger motor vehicles, and 60 horse-drawn vehicles. When the road is improved the figures for motor traffic will be more than doubled.

No material is available for surfacing along the entire road and all such material will have to be obtained from commercial sources and shipped by rail to points along the project. The type of surfacing is to be monolithic brick from Granite City to Mitchell and concrete pavement for the remainder of the distance. The average cost per mile for the project is approximately $27,000.

COMPLETING THE OLD NATIONAL ROAD.

Project No. 9, which will undoubtedly hold the record for length and cost for some time to come, is of unusual interest aside from its great length and cost. It contemplates, after the lapse of nearly a century, the completion of the Old National Road, extending from the Potomac to the Mississippi, which already has been largely improved as far west as the Indiana line. The Illinois improvement will extend from East St. Louis across the State to the Indiana line, traversing St. Clair, Madison, Bond, Fayette, Effingham, Cumberland, and Clark Counties.

The proposed type of surface is monolithic brick and concrete pavement, the average cost of which is about $30,000 per mile. The proposed improvement includes also the construction of 40 bridge structures of lengths ranging from 22 feet to 300 feet. At present the highway is generally an unimproved earth road which becomes nearly impassable at cer-

tain seasons of the year. There are, however, near some of the villages short stretches of macadam pavement, generally in very poor condition. The local traffic consists of approximately 60 trucks, 700 motor vehicles, and 50 horse-drawn vehicles per day, to which is added during the summer months a through traffic of about 20 trucks, and 200 passenger motor vehicles.

More than a century ago after a lengthy debate and a hard fight, Albert Gallatin, ably seconded by Henry Clay, succeeded in getting an act passed and approved by President Jefferson on March 29, 1806, appropriating $30,000 for the survey and construction of a National Road leading from the Potomac at Cumberland, Md., to the Ohio River opposite Steubenville. This famous highway was finished as far as Wheeling, a distance of 132 miles in 1820, although coaches carrying Government mail started using the road on August 1, 1818.

THE FIRST HIGHWAY.

The highway was cleared for a width of 80 feet and surfaced with broken stone 20 feet wide, 18 inches thick at the center and 12 inches thick at the edges. The upper 6 inches of stone was broken to pass through a 3-inch ring and the bottom course stone was of a size that would pass a 7-inch ring. The filling and binding material was mostly gravel and the whole compacted with a 3-ton iron faced roller 4 feet in length. Earth shoulders 6 feet wide were provided on each side of the broken stone, making the available travel way 32 feet. The maximum grade was 5°, or as usually expressed by modern highway engineers, about 8.7 per cent.

On May 15, 1820, an act of Congress provided $10,000 for laying out the plans of the road from Wheeling to the Mississippi by way of Columbus, Indianapolis, and Terre Haute to St. Louis. Indianapolis at that time contained about 150 houses, mostly of logs, and a courthouse, a jail, and three churches. The Mississippi River then represented practically the extreme western boundry of our inhabited area, as beyond that line, except in Louisiana and Missouri, not over 30,000 inhabitants were to be found. This new section of the National Road was surfaced from Wheeling as far as Columbus and construction had progressed as far west as Illinois when the development of the steam railroad as a transportation agency in 1838 put an end to further work and the entire road was taken over and operated by the various States as a toll road. When it is realized that freight charges over the National Road from Wheeling to Baltimore were $45 per ton, it is readily understood how the newly completed Baltimore & Ohio Railroad could so completely destroy the usefulness of the highway as a means of transporting freight. The work had been progressing for 32 years, and although it was to have been built by the Government out of funds derived from the sale of public lands in the States through which it passed, it was found necessary for the Government to contribute about $7,000,000 for construction purposes between 1806 and 1838.

EARLY DAY TRAFFIC.

The following interesting account of the stage coach activity on the Old National Road is found in Ringwalt's Development of Transportation Systems in the United States: "At various times four companies engaged in staging. They were the National Line, Good Fortune, June Bug, and The Pioneer stage lines. Relays were established at a distance of from 10 to 12 miles and there are some records of quick changing that would make a modern Gehu turn green with envy. An old driver still boasts of harnessing his four horses in four minutes and of changing teams before the stage ceased rocking. Ponderous trunks were strictly forbidden, each passenger being limited to 50 pounds baggage and there was careful weighing in those days. Each stage complement consisted in not more than nine passengers. As many as 14 coaches have traveled together with their one hundred-odd passengers.

"In those days the mail coaches left Wheeling at 6 a. m. and just 24 hours later dashed into Cumberland, having traversed a distance of 132 miles. Occasionally there were delays, but these were not permitted upon the completion of the Baltimore & Ohio Railroad to Cumberland. * * * At that date most of the freight for the West was conveyed from Baltimore and Frederick to Wheeling and points in the West with the old Conestoga wagons which, together with the numerous droves of cattle, sheep, and hogs driven to market, frequently caused great obstruction to the stage coaches in getting by and through them.

"In 1846 when the Baltimore & Ohio Railroad reached Cumberland the travel over the National Road was greatly increased. Competitive stage lines were put on and it was no unusual thing to see from 15 to 20 coaches leave and enter Cumberland twice a day. The great stream of travel between the East and West poured over the National Road from that time on for several years. In 1852 the Baltimore & Ohio Railroad reached the Ohio River and it remained for the son of the father who started the first line of stage coaches across the Allegheny Mountains with the daily mail to carry the last mail for the East by coach."

INDIANA BEGINS BIG PROGRAM.

Indiana makes its appearance in the list of project statements approved in June. Indiana, as did other States, passed a law to enable that State to take ad-

vantage of the Federal aid act soon after it was placed on the statute books. In the first year of the operation of the law a half dozen or more Indiana applications were made for Federal aid. They were held up by an attack on the Indiana law in the courts of that State. It was not until last winter that final decision in the case was rendered by the Indiana Supreme Court, upholding the constitutionality of the law. In the meantime, however, a bill had been introduced into the legislature of 1919 for a new highway law, which was afterwards passed. Under this new law the State highway commission was reorganized and a road program was later adopted. Now Indiana is prepared to go forward in harmony with other States in rapid highway building in cooperation with the Federal aid law.

The first evidence of this fact was in June, when six project statements were submitted to the Bureau of Public Roads which were approved before the end of the month. The six projects cover 113.6 miles of road and their estimated cost aggregates $4,585,238.88. This is an average of over $40,374 a mile. All these roads are to be of brick, concrete or bituminous concrete.

Two of the projects are very large ones, among the largest projects so far submitted from any State. The larger of the two is for 35.3 miles of road in Hancock and Henry Counties, and has an estimated cost of $1,419,928, or about $40,225 a mile. The other is for 35.1 miles in Vigo, Clay, and Putnam Counties and its estimated cost is $1,394,016.80, or $39,713 a mile. This is a revision of a project approved nearly two years ago. In the table only the increased figures are given. These two projects are for stretches of the Old National Road in Indiana, the former lying between Indianapolis and Richmond and the latter between Terre Haute and Indianapolis. A third project for a stretch of this road submitted is for 14.7 miles between Terre Haute and Indianapolis, in Hendricks County, estimated to cost $610,606. These three projects will practically carry the rebuilding of the Old National Road across Indiana, and with the big Illinois project will about complete the reconstruction of that road from St. Louis to the Ohio-Indiana boundary line.

Two of the other Indiana projects filed in June are for stretches on the Lincoln Highway in Elkhart and St. Joseph Counties. One of these will cost $46,790 a mile. The remaining one is a part of the Michigan road, in Marshall and St. Joseph Counties, a north and south highway. All the projects are portions of the established State highway system of the State, to be built and maintained by the State highway commission. The funds for building and maintaining State highways are provided by a tax of 10 cents on the $100 of property valuation, fees from motor and chauffeurs licenses and from inheritance taxes.

FEATURES OF THE MONTH.

The two Illinois projects approved in June together call for Federal aid to the amount of $3,392,580.80, with an estimated cost of $6,785,161.60 for 236.70 miles of brick and concrete roads.

Indiana's record for the month comes next to that of Illinois, in the amount of Federal aid allowance and in the estimated cost of the projects. The Federal aid allowance for Ohio projects amounts to $1,120,350 on an estimated cost of $3,265,154. Pennsylvania projects are estimated to cost $2,077,903.08, with Federal aid of $913,374.85, while West Virginia comes to the front with a number of important projects, estimated to cost $1,248,841.84, for which the Federal aid allowance is $691,791.36.

In the number of projects approved Nebraska leads with 19 and the mileage of these projects, 385.31, also puts that State at the top of the list in the length of roads to be improved. Ohio had 17 projects approved, with a total length of 92.65 miles. New Hampshire comes third in the number of approvals, 16, but all of them together have a mileage of only 18.09 miles.

In agreements executed during the month Pennsylvania leads in number with 6 originals and 14 modifications and Iowa in mileage, 71.69. Pennsylvania will receive $1,170,958.85 of Federal aid for projects which will cost $2,053,471.20. New York follows in the estimated cost of roads and in the Federal aid allowance for agreements signed, while Ohio is third. The New York roads will cost $1,187,364, with Federal aid of $586,932.17. The Ohio roads will receive Federal aid amounting to $360,674.52, on an estimated cost of $1,028,565.72.

Of the 1,426.8 miles of road covered by the statements approved during the month nearly one-half are to be either concrete, brick, bituminous, or bituminous macadam.

One Ohio project, 6.6 miles long, will cost an average of $65,909 a mile. Other high cost roads are 7.08 miles in New York to be built at an average of $60,464, and 16.6 miles in Kansas, the cost of which will average $55,473.

FEDERAL BID PROJECT APPROVALS AND AGREEMENTS IN JUNE, 1919.

State.	Project number.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Alabama	11	Lowndes		Gravel	June 16		[1] 6,466.29	[1] 3,249.49
	13	Calhoun		Chert		June 19	[2] 10,032.00	[2] 5,016.00
	55	Jefferson	5.00	Asphalt, brick, or concrete	June 30		174,295.55	87,147.77
	56	do	3.83	do	do		138,874.45	69,437.22
	57	do	6.00	do	do		220,184.80	110,092.40
Arkansas	21	St. Francis	7.93	Gravel		June 19	34,333.72	15,000.00
California	8A	Trinity	11.40	Graded and drained earth		June 2	310,984.30	155,492.15
	10	Modoc	10.85	Graded earth		do	78,717.65	39,358.82
	19	Mendocino	9.74	Earth	June 7		116,424.00	58,212.00
	20	Lake	9.36	do	June 5		116,798.00	58,399.00
Colorado	17	El Paso	2.27	Earth and sand-clay	June 7		31,075.00	15,537.50
Delaware	4	Sussex	4.39	Concrete		June 19	168,408.60	84,204.30
Georgia	23	Forsyth	11.20	Sand-clay	June 18		52,266.50	25,000.00
	54	Floyd	2.80	Concrete	June 7		96,332.39	48,166.19
	68	Walton	9.00	Sand-clay	June 3		69,982.00	34,991.00
	74	Sumter		3 bridges	June 2		17,352.50	8,676.25
Illinois	8	Madison, Macoupin Sangamon	86.20	Brick and concrete	June 30		2,321,650.00	1,160,825.00
	9	St. Clair, Madison, Bond, Fayette, Effingham, Cumberland, and Clark.	155.50	do	June 26		4,463,511.60	2,231,755.80
Indiana	1	Elkhart	[1] 1.50	Brick, concrete, or bituminous concrete	June 20		[1] 81,488.00	[1] 59,444.00
	6	Vigo, Clay, and Putnam	[1] 28.85	do	June 19		[1] 1,286,496.80	[1] 619,500.00
	10	Marshall, St. Joseph	19.00	do	June 18		769,032.00	380,000.00
	11	St. Joseph, Elkhart	3.50	do	do		163,768.00	70,000.00
	13	Hancock, Henry	35.30	do	June 30		1,419,928.00	709,964.00
	15	Hendricks	14.70	do	do		610,606.00	305,303.00
Iowa	3	Jefferson	[2] .75	Graded earth		June 21	[2] 16,603.13	[2] 18,169.45
	9	Johnson	10.89	Brick, concrete, and earth		June 7	79,889.54	23,859.55
	16	Montgomery	15.93	Earth		do	95,469.97	45,000.00
	22	Linn	18.00	Brick, concrete, gravel, and earth		June 23	189,979.97	27,718.86
	25	Black Hawk	4.05	Brick, asphalt, or concrete		June 19	168,412.04	46,881.28
	28	Sioux	24.25	Earth	June 9		65,780.00	29,381.20
	31	Howard	10.40	Gravel		June 9	55,517.44	27,000.00
	35	Chickasaw	13.17	do		June 12	85,292.54	42,000.00
	38	Plymouth	27.85	Earth	June 16		71,621.00	33,285.80
	44	Cass	19.60	do	June 3		75,856.00	21,804.00
Kansas	28	Ford	16.60	Brick or concrete	June 19		920,856.20	249,000.00
Kentucky	1	Boyd		do		June 27	[2] 53,612.22	[2] 53,781.94
	4	Carter	[2] .04	Earth		do	[2] 21,415.83	[2] 10,707.91
	5	Mercer		Macadam		do	[2] 16,804.87	[2] 8,402.4
Louisiana	22	Rapides	1.66	Bituminous macadam		June 4	67,845.63	33,92..81
	28	Iberia		Gravel		June 12	[2] 14,827.97	[2] 8,541.59
	31	Avoyelles		do		June 26	[2] 4,345.18	[2] 2,172.59
	32	Grant	20.23	do	June 19		214,629.58	107,314.79
	35	Jefferson Davis	7.50	Sand-clay and gravel	June 7		64,589.66	32,294.83
	36	Tangipahoe	12.56	Gravel	June 23		110,777.75	55,388.87
Maine	4	Penobscot	7.05	do	June 5		108,765.80	54,382.90
Massachusetts	21	Berkshire	3.645	Concrete	June 23		148,401.00	72,900.00
Maryland	6B	Prince Georges, Howard, Baltimore.	11.60	do		June 21	191,554.89	95,777.45
	11	Frederick	1.86	do		June 9	71,596.91	35,798.45
	13	Prince Georges	1.67	do		do	61,670.54	30,835.27
	19	Wicomico	1.53	do		June 21	54,691.01	27,345.50
	21	Kent	3.02	do		do	83,953.16	41,976.58
	23	Caroline	.65	do		June 9	19,795.01	9,897.50
Michigan	16A	Washtenaw		Concrete, asphaltic concrete, or brick		June 17		9,527.30
	30	Case	7.095	Concrete or bituminous		June 19	189,496.07	94,748.03
	31	Berrien and Van Buren	6.718	do		June 4	198,911.70	99,455.85
Minnesota	6	Carver		Graded and drained earth		June 26	[2] 50,146.59	[2] 20,000.00
	14	do		Gravel		do	([3])	([3])
	37	Hennepin	5.50	Asphalt, brick, or concrete	June 30		197,627.10	40,000.00
	45	Nobles	19.95	Gravel	June 18		114,620.00	57,310.00
	47	Pope	16.50	do	do		74,475.53	37,237.76
	48	Swift	12.15	Pavement and gravel	June 20		261,646.00	120,000.00
	50	Mahnomen	4.00	Gravel	June 13		15,158.00	7,579.00
	58	Nobles	5.50	Concrete, brick, or asphalt	June 19		138,050.00	60,000.00
	59	Becker	3.80	Gravel	June 4		18,162.32	9,081.16
	61	Freeborn	14.70	do	June 20		85,716.40	42,858.20
	62	Dodge	5.75	do	June 18		32,736.16	16,368.08
Mississippi	22	Benton	11.82	do		June 20	109,358.03	54,679.01
	24	Marshall	6.98	do		June 4	39,325.00	10,000.00
Missouri	8	Harrison	9.39	Concrete and macadam		June 23	165,299.38	82,649.69
	9	Jefferson	9.39	Gravel and macadam		June 25	46,934.51	23,467.26
Montana	33	Musselshell	4.25	Earth and gravel	June 24		21,547.68	10,773.84
	40	Gallatin	2.75	Gravel and macadam	June 26		18,393.92	9,196.96
	41	do	5.00	do	June 30		30,140.00	15,070.00
Nebraska	18	Gage and Lancaster	36.96	Earth		June 23	113,978.57	56,989.28
	20	Lancaster	[1] 6.20	do	June 3		[1] 17,050.00	[1] 8,525.00
	21	Douglas		do		June 23	[2] 5,588.22	[2] 2,794.11
	30	Furnas	21.50	do	June 16		32,554.50	16,277.25
	31	Dixon	16.93	do		June 23	60,689.07	30,334.53
	34	Garfield	9.76	Earth and sand-clay	June 16		16,142.50	8,071.25
	44	Sherman	3.50	Earth	June 6		8,085.00	4,042.50
	46	Red Willow	17.20	do	June 3		52,806.00	26,400.00
	50	Merrick and Nance	29.60	do	June 16		59,620.00	29,810.00
	53	Boone and Nance	21.60	do		June 4	69,375.74	34,687.87
	58	Colfax	18.35	do	June 16		26,730.00	13,365.00
	63	Hayes and Perkins	41.50	do	June 4		77,000.00	38,500.00
	65	Greeley	18.50	do	June 23		45,320.00	22,660.00
	67	Furnas and Red Willow	39.50	do	June 20		85,800.00	42,900.00
	72	Cedar	22.00	do	June 3		46,750.00	23,375.00
	75	Fillmore and Thayer	19.30	do	June 16		44,792.00	22,396.00
	77	Adams	11.50	do	June 2		24,640.00	12,320.00
	78	Douglas	13.00	do	June 16		33,000.00	16,500.00
	82	Garden and Morrill	32.10	Earth and sand-clay	June 30		72,270.00	36,135.00
	86	Butler and Polk	17.00	Earth, gravel, and concrete	June 23		64,735.00	32,367.5[illegible]
	91	Douglas and Washington	16.50	Earth	June 5		48,400.00	24,200.00
	92	Buffalo and Sherman	15.00	do	June 30		44,440.00	22,220.00
	98	Saline and Lancaster	33.30	do	do		72,600.00	36,300.00

[1] Revisions of project statements previously approved. Figures given are increases over amounts in original statements.
[2] Modified agreements. Amounts given are increases over those in original agreements.
[3] Canceled.

FEDERAL BID PROJECT APPROVALS AND AGREEMENTS IN JUNE, 1919—Continued.

State.	Project number.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Nevada	7	Washoe		Gravel and macadam		June 23	[1] 203,840.34	[1] 101,920.00
	14	Douglas	3.45	Gravel		June 4	26,847.70	13,423.85
	15	Elko	8.34	Earth		June 2	42,269.15	21,134.57
	23	Mineral	10.00	do	June 2		148,060.00	74,030.00
New Hampshire	8	Sullivan		Telford base with asphalt surface		June 26	[1] 7,041.08	[1] 3,520.54
	28	Grafton and Merrimack	1.10	Gravel	June 23		14,808.20	7,404.10
	29	Merrimack	.49	do	do		5,974.43	2,987.21
	30	Grafton	.38	do	do		5,192.22	2,596.11
	31	do	.46	do	do		5,382.19	2,691.09
	36	Cheshire	1.34	do	June 18		12,549.02	6,495.39
	39	Grafton	.73	do	June 23		9,983.27	4,991.63
	40	Merrimack	1.25	do	June 16		9,082.48	4,541.24
	41	do	1.25	do	do		9,900.00	4,950.00
	42	Stafford	1.50	do	June 23		12,549.02	6,495.39
	43	Rockingham	1.26	do	do		10,063.84	5,031.92
	44	Cheshire	.348	Bituminous	June 24		13,297.77	6,648.88
	49	Belknap	1.25	Gravel	June 30		9,900.00	4,950.00
	50	Cheshire	1.25	Bituminous macadam	do		19,929.47	9,964.73
	51	do	.86	Bituminous	June 23		15,708.02	7,854.01
	53	Grafton	3.62	Gravel	do		45,206.43	22,603.21
	59	Cheshire	1.00	Macadam	do		19,321.28	9,660.64
New Mexico	20	Lincoln	7.00	Gravel	June 30		59,061.20	29,530.60
New York	1	Chautauqua	4.64	Concrete		June 26	144,956.35	72,478.17
	3	Chenango		Bituminous macadam		June 12	[1] 233,800.00	[1] 116,900.00
	4	Chautauqua		Concrete		June 26	[1] 61,400.00	[1] 30,000.00
	5	Columbia	7.34	Macadam or concrete		do	293,600.00	146,800.00
	9	Fulton		Macadam with surface application of tar.		June 19	[1] 15,508.00	[1] 7,754.00
	23	Schoharie	2.76	Concrete	June 2		94,100.00	47,050.00
	30	Cattaraugus	7.08	do	June 27	June 30	438,100.00	212,300.00
North Carolina	23	Burke		Topsoil		June 23		[1] 7,500.00
	37	Gaston	10.38	Bituminous macadam		June 7	167,173.23	83,586.61
	45	Buncombe	7 71	Macadam	June 30		229,447.44	114,723.72
North Dakota	3	Williams		Earth		June 23	[1] 13,150.26	[1] 6,575.13
	10	Pierce		Gravel		June 20	[1] 3,475.83	[1] 1,737.92
	24	Stutsman	25.90	Graded earth		June 26	92,336.51	46,168.25
	31	La Moure	4.79	Graded and drained		June 24	33,522.50	16,761.25
Ohio	4	Lake		Semimonolithic brick		June 4	[1] 19,590.72	
	13	Williams	2.05	Concrete, bituminous concrete, or bituminous macadam.		June 19	72,000.00	21,674.52
	20	Richland	3.38	Brick or concrete		June 27	119,000.00	40,000.00
	26	Van Wert	10.75	Concrete or bituminous macadam		June 19	292,815.00	107,500.00
	27	Hamilton	6.60	Asphalt, concrete, or brick	June 30		435,000.00	132,000.00
	33P	Clinton	3.88	Macadam		June 7	54,250.00	17,262.00
	33Q	do	5.58	do		do	77,450.00	22,736.00
	38	Auglaize	6.53	Brick, concrete, or bituminous		June 19	261,500.00	119,500.00
	46	Ashland	3.80	Concrete or brick		do	131,960.00	32,000.00
	50	Columbiana and Mahoning	4.12	Brick	June 23		152,027.30	51,000.00
	56	Montgomery	6.05	Concrete	June 3		210,000.00	70,000.00
	59	Fayette	12.80	Macadam or bituminous	June 19		305,400.00	128,000.00
	61	Wayne	4.08	Brick, concrete, or bituminous	June 23		136,000.00	50,000.00
	62	Morrow	2.56	Bituminous or concrete	June 26		101,876.94	40,000.00
	66	Defiance	2.04	Concrete	June 20		55,500.00	27,750.00
	67	Logan	11.23	Concrete	June 3		428,000.00	175,000.00
	68	Perry	4.84	Bituminous or concrete	June 20		185,000.00	66,100.00
	75	Belmont	4.00	Macadam	June 18		99,890.42	40,000.00
	76	do	4.45	do	June 7		105.000.00	40,000.00
	77	Williams	2.98	Concrete	do		109,722.80	35.000.00
	78	Mahoning and Columbiana	2.15	Brick	June 3		93,657.57	15,000.00
	79	Fulton	6.20	Macadam or concrete	June 20		205,779.64	62,000.00
	81	Pickaway	5.07	Macadam or bituminous	June 26		163,300.00	50,700.00
	87	Champaign	5.07	Concrete	June 30		178,000.00	50,700.00
	88	do	8.41	do	do		301,000.00	84,100.00
Pennsylvania	1	Clarion		Vitrified brick on concrete foundation		June 7	[1] 43,074.85	[1] 26,750.00
	2	Washington		Reinforced concrete		June 9	[1] 240,698.87	[1] 64,800.00
	3	Cambria		Brick on concrete base		June 10	[1] 122,548.74	[1] 62,340.00
	4	McKean		Vitrified brick		June 9		[1] 22,900.00
	5	Somerset		Reinforced concrete or bituminous, concrete or vitrified.		June 7		[1] 54,108.53
	6	Blair		Bituminous concrete		June 9	[1] 37,829.56	[1] 30,100.00
	8B	Erie		Cement concrete or bituminous concrete on concrete base.		June 12	[1] 31,485.06	[1] 17,188.33
	9	Butler		Reinforced concrete		do	[1] 19,929.91	[1] 29,042.41
	10	Lawrence		do		June 7		[1] 22,900.00
	11	Lycoming		do		do		[1] 55,079.19
	12	Northampton		do		June 19	[1] 99,392.12	[1] 54,500.00
	15A	Beaver		Concrete, bituminous concrete, or reinforced concrete.		June 7		[1] 10,060.00
	16	Butler		Reinforced concrete		June 9		[1] 33,300.00
	17A	Dauphin, Lebanon, Berks	[2] 4.32	Concrete		June 7	[1] 51,266.85	[1] 54,427.87
	17 B&C	do	13.15	do		do	320,170.28	160,085.13
	23	Greene	6.49	Brick or concrete		June 9	358,039.05	129,800.00
	31	Center	6.10	Bituminous and brick		June 12	274,155.45	122,000.00
	32	Chester	4.10	Concrete		June 19	165,344.87	82,000.00
	33A	Luzerne	4.25	Bituminous and concrete		do	176,867.35	85,000.00
	33B	do	2.00	do		do	112,668.24	40,000.00
	36	Blair	2.58	Concrete	June 16		119,006.80	51,600.00
	37	Butler	6.10	Concrete or bituminous	June 5		294,248.90	122,000.00
	38	Crawford	3.13	do	do		147,116.20	62,600.00
	39	Dauphin	6.40	Concrete or brick	do		314,466.90	128,000.0
	40	McKean	10.11	Concrete	do		454,985.10	206,698.45
	41	Mercer	3.39	Concrete or bituminous	do		146,139.40	67,800.00
	42	Union	2.55	do	do		95,752.80	47,876.40
	43	Wayne	5.24	do	do		256,594.80	104,800.00
	44	Cambria	6.10	Concrete	June 30		249,792.18	122,000.00
Rhode Island	1	Washington		Bituminous concrete		June 26	[1] 2,952.98	
	2	do		Bituminous macadam		June 12		[2] −12,201.05
	3	do		do		June 25	[2] −5,033.55	[2] −2,516.78
	4	do	5.00	Bituminous		June 4	128,390.02	64,195.01
South Carolina	6	Marion	3.53	Mostly bridges		June 17	86,644.50	43,322.25

[1] Modified agreements. Amounts given are increases over those in the original agreements.
[2] Modified agreements. Amounts given are reductions from those in original agreements.

FEDERAL BID PROJECT APPROVALS AND AGREEMENTS IN JUNE, 1919—Continued.

State.	Project number.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
South Dakota	4	Brookings	6.46	Gravel		June 23	29,908.60	14,954.30
	13	Dawson	14.00	....do	June 23		58,113.00	29,056.50
	14	Stanley	18.50	Earth and gravel	..do		84,862.25	42,431.12
	15	Lawrence	22.94	....do	June 26		146,650.90	73,325.45
Texas	9	Lee	6.35	Gravel, concrete culverts		June 16	29,024.15	13,860.00
	21	Gregg		Bitumilus macadam		June 23	[1] 27,750.84	[1] 14,123.42
	69	Aransas	10.00	Bituminous gravel		..do	40,028.64	13,841.88
	83	Brown	10.98		June 24		91,293.55	22,500.00
Utah	5	Grand	35.10	Graded earth		June 25	135,204.18	67,602.09
	6	Grand and San Juan	23.80	....do		..do	144,385.45	72,192.72
Vermont	7	Windham	1.65	Gravel		June 18	24,190.43	12,095.21
	9	Orleans	2.88	....do		June 4	52,090.17	26,045.08
	10	Rutland	4.30	....do		June 30	68,702.31	34,351.15
Virginia	37	Bedford and Campbell	6.60	Bituminous	June 20		127,600.00	63,800.00
	38	Accomac	2.59	....do	..do		36,080.00	18,040.00
	45	Henry	4.50	Sand-clay	June 30		42,487.50	21,243.75
	48	Amherst and Bedford	19.10	Macadam	..do		303,105.00	151,552.50
	49	Caroline and Spotsylvania	.30	Gravel	June 18		8,805.50	4,402.75
	50	Campbell	2.10	Macadam	June 20		43,120.00	21,560.00
Washington	11	Lewis	.35	Concrete bridge and gravel approaches.		June 19	141,814.23	70,907.10
	27	....do	6.70	Concrete	June 19		190,388.00	95,194.00
	28	Snohomish	1.10	...do	do		37,374.33	18,687.16
	29	Grays Harbor and Jefferson	17.95	Gravel	June 20		265,628.00	132,814.00
	30	Skagit	7.70	Concrete	June 3		241,392.91	120,696.45
	31	Lewis		Bridge	..do		37,999.50	18,999.75
	32	Cowlitz	6.67	Gravel	June 18		271,250.10	133,400.00
	34	Clarke	6.70	Concrete	June 20		204,809.00	100,000.00
West Virginia	14	Mingo		Earth		June 16		[1] 18,925.00
	18	Tyler		Concrete		June 19	[2] −1,687.93	
	34	Monroe	2.00	Macadam		June 12	19,200.00	9,600.00
	39	Doddridge	3.00	Concrete	June 3		70,963.20	29,780.00
	40	Wood	2.00	....do	June 12		36,000.00	18,000.00
	41	....do	3.00	....do	June 16		56,000.00	25,300.00
	45	Putnam	4.00	Brick, concrete, or bituminous	June 18		140,360.00	48,000.00
	46	Ohio	1.00	Concrete	June 19		38,000.00	18,000.00
	47	Wetzel	4.74	....do	June 20		83,299.15	41,649.57
Wisconsin	7	Wakesha		Waterbound macadam		June 12	[2] −659.38	[1] 219.79
	19	Price		Graded earth		..do	[1] 3,911.71	[1] 1,303.91
	80	Green	5.41	Earth	June 2		41,160.00	13,720.00
	86	Lafayette	3.46	....do	June 16		33,593.70	11,197.90
	92	Brown	5.16	Concrete	June 2		116,980.00	38,993.57
	95	Milwaukee		Bridge	June 7		55,000.00	18,333.33
Wyoming	[3] 3	Lincoln			June 5			
	25	Crook	19.25	Earth	June 7		156,156.44	78,078.22
	28	Sheridan	4.16	Macadam	June 20		52,514.00	26,257.00
	34	Lincoln	17.64	....do	June 7		100,597.20	50,298.60
	35	Platte	12.74	Gravel	June 19		90,799.28	45,399.64
Total	239		1,939.23				34,519,971.11	16,102,244.59

[1] Modified agreements. Amounts given are increased over those in the original agreements.
[2] Modified agreement. Amounts given are reductions from those in original agreement.
[3] Statement previously approved withdrawn.

PLANS FOR BIG ROAD WORK.

Pottawattomie County, Iowa, will vote in September on a bond issue of $3,000,000 for roads. If the election is in favor of the bonds, it is estimated that the county will spend on its roads $5,000,000 according to plans now under preparation by the board of supervisors. The additional $2,000,000 is expected to come from State and National aid. Clay County, Iowa, will vote July 22 on a road bond issue of $800,000.

CALIFORNIA COUNTY BONDS.

So far this year California counties have voted $30,000,000 in highway bonds. Their proceeds are for the building of laterals to the State highway system roads or for the improvement of county systems. At recent elections Fresno County voted $4,800,000, San Diego $2,500,000, Sonoma $1,640,000, Imperial $1,500,000, Marin and Yolo $1,000,000 each, Santa Cruz $924,000, Napa $500,000 and Modoc $400,000. The first issue of the Fresno bonds, $1,000,000, and the Santa Cruz issue have already been sold at satisfactory premiums.

GEORGIA COUNTIES VOTE BONDS.

Several Georgia counties have recently cast decisive votes in favor of proposed issues of road bonds. Chatham County, in which Savannah is located, voted June 24 in favor of an issue of $2,500,000. It is planned to make use of the funds provided at an early date in starting road construction.

Ware County, in the southern part of the State, voted by nearly 19 to 1 in favor of bonds to the amount of $630,000, while the proposed issue of $400,000 in Mitchell County, also in south Georgia, was carried by about 4 to 1. Dougherty County has sold $400,000 of bonds to local banks at par, the bidders to pay for engraving the bonds and to pay interest on daily balances at 4½ per cent, the same rate the bonds bear. Grady County has voted to issue $250,000 in bonds.

FOR HIGHWAY BONDS.

Pittsylvania County, Va., will vote in September on an issue of road bonds to the amount of $300,000.

PRIMARY ROAD MAINTENANCE COSTS

Two Years' Record of the State of Washington

By E. G. COTTERILL, Chief Engineer, State Highway Commission.

ON June 7, 1917, the State of Washington inaugurated the plan of State-controlled, county-administered maintenance of its primary highway system. State funds, derived from the motor-vehicle license revenue, are apportioned to the counties "for the sole purpose of maintaining and repairing primary and permanent highways or highways of like character and for equipment for the maintenance thereof." The primary highways are required to be maintained by the counties "under such rules, regulations, and requirements as may be prescribed by the State highway board." In case any county administration is delinquent or deficient in maintaining any section of primary highway up to the prescribed standards, the law authorizes direct maintenance by the State highway department at the expense of the county apportionment of funds until the delinquency is overcome.

THE MAINTENANCE SYSTEM

At the outset, 1,245 miles of constructed primary highways came under the operation of this system of State control of county administered maintenance. By June of 1918, the mileage had increased by completion of new construction to 1,410 miles, and at this writing (July, 1919) by completed construction and additional routes designated by the recent legislature as primary highways, a total of 1,796 miles is under the joint maintenance plan. This will continue to increase at the rate of 200 to 300 miles annually for the next three or four years until the entire 2,700 miles of designated primary highway system is completed with permanent construction.

Although this primary mileage comprises only about 5 per cent of the established road system throughout the State (excluding streets withinc orporate limits of cities and towns), it is certain that at least 50 and perhaps as much as 75 per cent of the entire volume of highway traffic is carried by these primary routes, upon which the through and local travel is concentrated.

The principle of making the upkeep of these primary highways a prior claim upon the motor-vehicle license revenue—whether administered by State or counties—is economically sound and has proved its adequacy in practice. Prior to 1919 the license schedule, graded generally on the basis of weight and horsepower, averaged about $7 per vehicle, and all the revenue (over cost of license administration, about 10 per cent of collections) was apportioned to the counties for maintenance. The 1919 legislature, desiring to increase the construction fund, practically doubled the license schedule to an average of about $16 per vehicle. This assures about $2,000,000 revenue in 1919 and probably $2,250,000 for 1920. The first $1,000,000 annually (after license administration expense), is required to be apportioned to the counties and municipalities for the maintenance and upkeep of the primary highways within their limits as a prior obligation. After meeting this adequately, any surplus in the county apportionments is available for maintenance of the county permanent highways other than on primary routes.

STATE CONTROLS MAINTENANCE

In the exercise of State control over county administration of primary highway maintenance, the State highway board in June, 1917, prescribed in detail the methods and standards to be applied and required, including a uniform system of cost-keeping and monthly reports, thus compiling a continuing cost record of the maintenance and repair expenditures upon each section of highway. This cost-keeping system includes the following main features:

(*a*) The primary highways in each county are divided into consecutive sections in accordance with their respective types of construction and surfacing.

(*b*) The county or maintenance engineer in charge prepared each December an "annual cost estimate" for each section of highway on a prescribed form providing for a distributed estimate against the following segregated cost items, viz, patrol, drainage, dragging and dressing, clearing, removing obstructions, resurfacing and repair, sprinkling, sanding, structures, safeguards and signs, industrial insurance, equipment and supplies, supervision and contingencies—the latter being 10 per cent of the sum of all items preceding. These annual cost estimates are reviewed, and modified as deemed necessary, by the county board of commissioners and finally are subject to approval of State highway commissioner. The approved estimate for each section becomes its advisory budget for ensuing calendar year and the total of all approved estimates in each county is set aside from the apportioned maintenance fund to meet the expenditures as they may be required.

(*c*) The engineer in charge prepares monthly reports of actual expenditures upon each section on a form segregated into cost items corresponding with the annual estimate, and extending in appropriate columns a simple system of budget bookkeeping for each item. The respective columns on each monthly report indicate "expenditure, month reported"; "previous months, calendar year"; "total to date, calendar year"; "budget balance (or *deficit)." Each monthly report is prepared in duplicate, one for the county record, the other certified to the State highway commissioner. There is thus provided and expenditure report cumulative each month, by which the responsible county and State authorities at all times have a permanent record of the physical and financial status of every section of primary State highway subject to their maintenance administration and control.

(*d*) Special forms provide for detail explanation of annual estimates and monthly charges for "equipment and supplies" and for "supervision," making a record of the apportionment of these general items as between the respective sections of highway upon which they are applied.

COST-KEEPING RECORDS.

Two years of cumulative cost-keeping records of Washington primary highway maintenance are now

available. They cover about 250 separate sections of highway averaging each nearly 6 miles length; including 11 types of construction and surfacing. Their maintenance is under the direct administration of 30 boards of county commissioners and their county or maintenance engineers in charge. With an average of about 50 miles of primary State highway in each county, the maintenance organization covers these along with the larger group of main county and tributary highways, making the necessary apportionments for "overhead" supervision equipment, etc., as between the respective groups.

NOTE.—It may be opportune to emphasize the point just stated as the economic basis which supports the argument for county administration of maintenance of primary State highways under State regulation, as compared with direct State administration. Inasmuch as every county has, and must continue in any event, its organization and equipment for the maintenance of several hundred miles of county highways over which it has sole jurisdiction, is not this existing county organization best equipped to most economically and efficiently cover the 50 to 100 miles of State highway within the same county territory? Is it wise or necessary to duplicate maintenance equipment and organizations by superimposing a separate State maintenance administration upon the relatively small proportion of primary highway mileage within each county? Will not a centralized State highway department control and direction of county maintenance administrations applied to primary State highways, with State authority to prescribe and enforce standards of maintenance, and with requirement of uniform cost-keeping and records of the expenditure of the State funds apportioned for the upkeep of these main roads, best serve the common public purpose? Moreover, will not the tendency be to expand the application of the State-prescribed standards and requirements for adequate maintenance of the primary highways, to the other main and tributary county highways and thus uplift and establish the entire highway maintenance plan and organization in all the counties? Thus runs the argument for the joint system of State control and county administration as in force in Washington. There is another side to this argument and there are some decided offsets in favor of the concentration of all trunk highway maintenance under direct State administration irrespective of county organizations and boundaries. The figures of comparative maintenance costs of similar roads in adjacent counties are suggestive of decided differences of efficiency between county organizations, which concentrated State administration should overcome.

The tabulated statements which follow are a summary of the expenditures charged against the primary highways of Washington for their maintenance, repair, and equipment therefor during the past two years (June, 1917, to May, 1919, inclusive), as reported by the county engineers in charge to the State highway commissioner. They are classified—

(A) By counties exercising direct administration.

(B) By highways, as designated in the State primary system.

(C) By types of construction and surfacing.

ALL CHARGES ON ROAD INCLUDED.

For correct understanding of the tabular statements and making fair comparisons therefrom, it must be borne in mind—

(*a*) That the expenditures listed and averaged per mile include all charges upon the entire road, its drainage, roadbed, slopes, shoulders, etc., as well as the pavement or surfacing—everything that has been necessary for the adequate maintenance, repair, and general upkeep of the highway.

(*b*) That equipment purchases make up about 15 per cent of the total expenditures, varying from nominal up to 50 per cent in the various counties, apportioned upon the respective highway sections to which applied. While this operates fairly as a general State average, there are disproportionate equipment charges as between the several counties, which will not work out in fair comparison until at least four or five years of continuous records on this plan are made available.

(*c*) That the traffic on the various sections of highways included in these statistics varies from 100 to 200 vehicles per day (in such counties as Adams and Franklin) up to 2,000 to 4,000 vehicles per day (in such counties as King, Pierce, and Spokane on the highways tributary to Seattle, Tacoma, and Spokane). Any comparisons between the relative county averages of cost of maintenance per mile must take this volume of traffic into consideration, especially in the case of macadam and gravel-surfaced highways.

(A) STATE OF WASHINGTON—PRIMARY HIGHWAYS.

Expenditures for maintenance, repairs, and equipment, June, 1917–May, 1919.

Name of county.	Year June, 1917–May, 1918.		Year June, 1918–May, 1919.		Annual average cost per mile-year.
	Mileage.	Cost per mile.	Mileage.	Cost per mile.	
Adams	25.28	$36.08	25.28	$112.58	$74.33
Asotin	2.27	283.10	2.27	50.00	166.55
Benton	38.84	359.38	44.67	390.40	374.86
Chelan	10.39	113.59	22.24	435.36	274.47
Clallam	76.45	267.31	76.74	522.80	395.05
Clarke	18.01	429.60	28.82	464.28	446.94
Columbia	19.63	557.11	23.46	447.35	502.23
Cowlitz	21.01	730.48	26.67	552.70	641.59
Douglas	23.17	108.68	31.69	432.51	270.60
Franklin	1.91	8.31	19.16	180.58	94.46
Garfield	5.78	982.49	5.78	288.80	635.65
Grant	20.68	143.89	38.31	246.67	195.28
Grays Harbor	69.93	596.88	76.17	864.53	730.70
Jefferson	31.84	237.67	34.81	334.25	285.96
King	119.68	928.16	119.68	954.65	941.41
Kittitas	75.88	219.68	98.28	159.71	189.70
Lewis	77.90	157.31	77.90	463.88	310.60
Lincoln	39.45	354.65	69.03	254.82	304.73
Mason	48.50	165.13	52.07	206.99	186.06
Pacific	37.56	139.70	55.65	375.61	257.65
Pierce	81.47	160.81	86.24	402.92	281.86
Skagit	27.00	536.20	27.25	417.14	476.67
Snohomish	42.41	234.48	44.12	157.36	195.92
Spokane	94.57	171.93	106.29	544.57	358.25
Stevens	8.91	164.62	8.91	339.08	251.85
Thurston	50.17	165.51	56.49	257.98	211.75
Walla Walla	40.55	320.58	45.69	297.81	309.20
Whatcom	13.48	163.03	21.06	227.85	195.44
Whitman	64.27	442.37	65.30	270.57	356.47
Yakima	118.85	173.77	122.76	291.63	232.70
30 counties	1,303.87	327.84	1,512.79	419.86	373.85

(*d*) In general, and to a marked extent in certain counties, the cost statistics are made higher than ordinary maintenance should be, by the inclusion of incidental improvements to the highways, such as occasional widenings, additional drainage facilities, bank protection along streams, providing guardrails and other safeguards of traffic, removing slides, etc. Most of the Washington primary highways are new construction of the past six years, and under a liberal application of the term "maintenance and repair" any defects or minor errors which are revealed by use and with the effects of the elements at recurring winter and flood seasons, are supplied and overcome from the maintenance funds. Thus, with the exception of pavements and structures, it can be demonstrated that the Washington primary highways have been decidedly improved by continuing maintenance more than they have been worn out by the traffic. Maintenance expenditures should tend to decrease in comparison with the record of the past two years because of these incidental improvements and repairs of new construction which have been liberally classified and charged to maintenance.

(B) STATE OF WASHINGTON—PRIMARY HIGHWAYS.

Expenditures for maintenance, repairs, and equipment, 1917–18.

Name of highway.	1917 (7 months June-Dec.).			1918 (full year).			1917–18, cost per mile-year.
	Mileage.	Expenditure.	Per mile.	Mileage.	Expenditure.	Per mile.	
Pacific Highway	237.54	$45,875.29	$193.13	258.09	$107,171.13	$415.25	$384.24
Sunset Highway	227.99	43,578.31	191.14	281.16	93,218.02	331.54	330.11
Inland Empire Highway	310.14	51,746.94	166.88	336.93	136,132.45	404.04	360.58
National Park Highway	124.39	5,884.58	47.31	155.59	54,592.82	350.87	251.48
Olympic Highway	232.36	41,878.38	180.23	250.55	111,288.96	444.18	394.36
McClellan Pass Highway	71.27	20,295.53	284.77	79.27	50,731.67	639.98	584.05
Central Washington Highway	41.88	1,570.86	37.51	48.94	6,633.43	135.54	109.30
Primary highway, Total	245.57	210,829.89	169.26	1,410.53	559,768.48	396.85	357.54

(C) EXPENDITURES 1917–18, CLASSIFIED BY HIGHWAY CONSTRUCTION TYPES.

Type of surfacing.	1917 (7 months June–December).			1918 (full year).			1917–18, cost per mile-year.
	Mileage.	Expenditure.	Per mile.	Mileage.	Expenditure.	Per mile.	
Brick Pavement [1]	8.81	$9,456.51	[1] $1,073.38	8.81	$6,652.29	[1] $755.08	$914.23
Cement concrete	90.59	5,110.60	56.41	102.38	11,427.54	111.61	106.12
Asphaltic concrete	19.74	322.21	16.32	23.24	7,871.09	338.68	224.21
Bitulithic and warrenite	14.41	3,040.50	211.00	17.77	5,143.54	289.45	316.07
Sheet asphalt	5.97	326.05	54.61	5.97	207.07	34.68	56.39
One-half width concrete, one-half width macadam, etc.	7.80	1,798.50	230.58	8.53	2,461.81	288.61	327.91
Bituminous macadam	42.21	5,895.67	139.67	40.96	20,071.85	490.03	397.70
Water-bound macadam	122.85	20,297.41	165.22	125.05	52,335.59	418.53	368.67
Crushed rock surfacing	54.03	8,396.81	155.41	66.30	32,063.53	483.61	403.59
Gravel surfacing	756.33	138,199.34	182.72	825.81	353,845.15	428.48	386.02
Natural earth grade	121.28	10,511.82	86.67	182.13	30,185.56	165.73	159.42
Special, bridges, trestles, etc	[2] 1.55	7,474.47	....	[2] 3.58	37,503.46	....	....
All types, total	1,245.57	210,829.89	169.26	1,410.53	559,768.48	396.85	357.54

[1] Abnormal expenditures on brick pavements due to extensive repairs and replacements account faulty construction and road-bed settlements. The 1917–18 average per mile year obtained by adding annual averages and equal division of sum. In all cases of other types than brick, the 1917–18 mile-year average is obtained by dividing sum of annual averages by 1.5833, on account 7 months of 1917 averaged with full year 1918.

[2] This item represents unusual expenditures on bridges, trestles, etc., such as replacements, redecking, etc., amounting practically to reconstruction, and therefore excluded from ordinary maintenance cost of the highway sections in which located.

ABNORMAL USE SWELLS COSTS.

(*e*) On certain sections of the McClellan Pass Highway in King County and of the Olympic Highway in Clallam and Grays Harbor Counties, the Federal Government spruce operations of the war period imposed a most abnormal and destructive use upon more than a hundred miles of gravel-surfaced highways. Extension trucks carried great logs, often to aggregate weights of 20 to 25 tons, over miles of roads unfitted for such abnormal use; but with no other transportation resource from the spruce forests, these roads were devoted to the national service. In order to keep up these roads under such traffic, it required on the McClellan Pass Highway in King County an expenditure during 1918 of $1,861.37 per mile for the 19-mile section east of Emmelaw, which was the scene of the spruce-hauling operations. Similarly on the Olympic Highway in Grays Harbor County south from Lake Quiniault it cost almost $1,000 per mile to keep up the 37 miles of gravel-surfaced highway during 1918. These abnormal upkeep costs swell the figures from these counties and types of highway.

(*f*) The years covered by these tabular statements, beginning with June, 1917, have witnessed the highest scale of labor and material costs ever known. Common labor had reached the $3.75 mark before June, 1917, and rose to $4.50 and $5 during 1918, at which level it remains in June, 1919 (for day of eight hours). This represents a full 100 per cent increase from the $2.25 to $2.75 rates for similar labor in the prewar period. And the materials necessary for maintenance work have risen in almost similar doubled proportion. The Washington primary highway average of almost $400 per mile maintenance cost in 1918—and five months of 1919 shows a continuance at about this rate—is fairly comparable with $200 per mile during the period of 1910–1916.

SAVING ON HARD-SURFACED ROADS.

At least one general conclusion is fairly deducible from the Washington figures of two years' maintenance costs, viz, that there is a gap of $250 to $300 per mile per year between the group of hard-surfaced paved highways and the macadam-gravel group. Considering further that the paved highways carry a volume of traffic per mile, averaging two to ten times that of the macadam-gravel group, it is demonstrable from detail analysis of sectional reports that macadam-gravel sections under traffic comparable with paved sections are costing from $600 per mile per year and upward for their upkeep. In other words the real gap between maintenance cost of paved and macadam-gravel highways under similar heavy traffic is at least $500 per mile per year. Assuming a traffic of 500 motor vehicles per day or 182,500 per year, it is certain that not less than 1 cent per mile—some would place it as high as 2 cents—will be saved to the motor operating public, or $1,825 per year per mile, in actual upkeep cost of motor vehicles employed, to say nothing of increased traction results, time saved and convenience served. Adding the $500 per mile of increased annual maintenance cost and $1,825 per mile of motor vehicle upkeep cost makes a showing of $2,325 per year per mile which can be saved by substituting a hard-surface pavement for macadam or gravel surfacing. Half this amount would pay the interest on an investment of $25,000 per mile in pavement.

Whenever the traffic on a macadam or gravel surfaced highway approaches an average of 500 motor vehicles daily, the Washington experience, demonstrates costs of $600 to $1,000 per mile for such uneffective degree of upkeep as is possible for these highway types under such traffic. In every such case a hard-surface pavement is economically over-due; and the Washington program is to get these roads up to date by hard-surface construction as fast as resources and credit will permit.

TEST AND RESEARCH INVESTIGATIONS OF THE BUREAU OF PUBLIC ROADS

By PRÉVOST HUBBARD, Chemical Engineer.

ON July 1, 1915, all of the testing and research work of the Bureau relating to road materials was consolidated under one head, thus creating the Division of Road Material Tests and Research. The work is divided under six main sections, each in charge of an investigator, who reports directly to the chief of the division. There is also a small clerical force and a machine shop, whose work is distributed as required. In addition to written reports from each section, progress of work is recorded on a large blueprint chart, copies of which are posted in the various offices and laboratories. This chart shows the monthly progress on each separate investigation which is undertaken, together with the names of employees engaged thereon. The following brief descriptions of investigations at present under way will serve to illustrate the scope and character of work performed by the division in addition to its regular routine testing and cooperation on Federal aid projects.

EFFECT OF MOTOR TRUCK TRAFFIC ON HIGHWAYS.

The recent heavy increase in motor truck traffic has brought forward problems of legislation, regarding the maximum weight and speed of motor trucks, which require immediate solution in order that adequate laws may be enacted to protect existing roads from rapid destruction and to furnish a guide for the design of future roads. Such legislation should, of course, be based only upon sound judgment and full investigation. At the present time, however, there is little definite knowledge regarding the relative destructive effects exerted by different weights of trucks operating at various speeds. It is known, of course, that a heavy truck exerts higher impact stresses than a light truck as may be readily observed by the relative vibration produced in slab pavements of any kind during the passing of heavy and light trucks. The effect of speed is known in a general way, but it is very desirable, in order to obtain definite knowledge on the relative destructive effects, that some measure be obtained of the impacts exerted by different sizes of trucks operating under different speeds. The tire question, too, is one that requires investigation in view of the claims made for the recently advocated large size pneumatic tires.

In order to obtain information upon these problems a series of tests is now being conducted at the Arlington Experimental Farm in which the impact effects of motor trucks are being measured. For this investigation, a scheme is employed similar to that used in the Ordnance Department of the Army for obtaining gun pressures. It consists in subjecting a small copper cylinder to the effect of the blow and measuring the resulting deformation of the cylinder.

The next step in a complete investigation of the destructive effects of truck loads is to actually subject test sections of roads to corresponding impact effects. A machine has been designed and is now being built which will exert the same kind of impact that is exerted by motor trucks. The machine consists of an unsprung weight together with a sprung weight as in the case of a motor truck. The entire weight is raised by means of a cam and allowed to drop a great number of times so that the impact will be exerted on the same spot. This machine will be used in testing pavement slabs laid directly on a prepared subgrade. It is the aim to include in this investigation a large number of typical road sections, including concrete of different thicknesses and proportions, both plain and reinforced; 3 and 4 inch brick pavements of various types, such as monolithic, semimonolithic, and sand-cushion construction, using repressed, wire-cut lug and vertical fiber brick, with bituminous as well as cement grout filler; and sections of bituminous concrete and other types of pavement with and without concrete base.

The scheme of testing contemplates continued impact action by means of the above described machine until noticeable failure occurs. It is proposed to make all the necessary deflection measurements that may be required during the progress of the test.

It is believed that as a result of these investigations it will be possible to state definitely that any designated type of road is capable of withstanding a definite number of vehicles per day when laid on a known kind of subgrade. It is proposed to make the tests on two kinds of subgrades, one that is well drained and one that is purposely kept in a soft condition. These are the two extreme conditions of subgrade on which the ordinary road is actually laid. The following slabs 7 and 14 feet square will be tested in the immediate future and additional sections of various pavements will be constructed for test at a later date.

1. Plain concrete:

2, 4, 6, 8, 10 inches thick by 7 feet square, also 6 inches thick by 14 feet square.	Poor subgrade.
Do	Good subgrade.

2. Monolithic construction—Wire-cut lug brick:
   - 1-inch screenings .... Good subgrade.
   - 1, 2, 4, 6 inch concrete base .... Poor subgrade.
   - Do .... Good subgrade.
   - 6-inch concrete base, soft brick .... Do.
3. Monolithic construction—Vertical fiber brick:
   - 4-inch, 6-inch concrete base .... Good subgrade.
4. Monolithic construction—Repressed brick:
   - 4-inch, 6-inch concrete base .... Good subgrade.
5. Semimonolithic construction—Wire-cut lug brick:
   - 4-inch, 6-inch concrete base .... Poor subgrade.
   - Do .... Good subgrade.
6. Sand cushion construction—Wire-cut lug brick:
   - 4-inch, 6-inch concrete base .... Poor subgrade.
   - Do .... Good subgrade.
   - 4-inch, 6-inch concrete base, using 1-inch screenings. Do.
7. Wire-cut lug brick—Grout filler:
   - 6-inch, 12-inch macadam foundation. Poor subgrade.
   - Do .... Good subgrade.
8. Vertical fiber brick—Bituminous filler:
   - 4-inch, 6-inch concrete base, sand-cement cushion. Poor subgrade.
   - 6-inch concrete base, sand-cement cushion. Good subgrade.
9. Vertical fiber brick—Bituminous filler:
   - 4-inch, 6-inch concrete base, sand cushion. Poor subgrade.
   - 6-inch concrete base, sand cushion. Good subgrade.
   - 4-inch, 6-inch concrete base, sand cement cushion screenings. Do.
10. Wire-cut lug—Bituminous mastic cushion and filler:
    - 4-inch, 6-inch .... Poor subgrade.
    - 6-inch .... Good subgrade.

WEAR TESTS OF PAVEMENT SECTIONS.

By means of a series of wear tests now in progress, it is hoped to obtain information of considerable value regarding some of the problems involved in the selection of materials for vitrified brick, stone block, and concrete pavements. In these tests the various materials are being subjected to wear in pavement sections, laid as in actual construction. In the brick and block sections this makes it possible to observe the influence exerted by different types of joint fillers and bedding courses. In other words, the constituents of a highway are tested in combination instead of separately as is the usual laboratory practice. A detailed layout of the various sections now under construction is as follows:

GROUP A—VITRIFIED BRICK.

Section No.	Type brick.	Grade of brick rattler loss per cent.	Type filler.	Type bed.
1	Repressed	16	Cement grout	1 inch sand-cement
2	Wire-cut lug	16	....do	Do.
3	Repressed	18	....do	Do.
4	Wire-cut lug	19	....do	Do.
5	Vertical fibre lug	19	....do	Do.
6	Repressed	24	....do	Do.
7	Wire-cut lug	23	....do	Do.
8	Repressed	16	Asphalt	1 inch sand.
9	Wire-cut lug	16	....do	Do.
10	Repressed	18	....do	Do.
11	Wire-cut lug	19	....do	Do.
12	Vertical fibre lug	19	....do	Do.
13	Repressed	24	....do	Do.
14	Wire-cut lug	23	....do	Do.
15	....do	19	....do	1 inch asphalt sand.
16	....do	19	Asphalt mastic	Do.

GROUP B—STONE BLOCK.

Section No.	Type block.	Grade of block fr. coeff. wear.	Type filler.	Type bed.
1	Granite	12	Cement grout	1 inch sand-cement.
2	....do	11	....do	Do.
3	....do	10	....do	Do.
4	....do	9	....do	Do.
5	....do	12	Asphalt	1 inch sand.
6	....do	11	....do	Do.
7	....do	10	....do	Do.
8	....do	9	....do	Do.
9	....do	12	Asphalt mastic	Do.
10	....do	11	....do	Do.
11	....do	10	....do	Do.
12	....do	9	....do	Do.
13	....do	12	....do	1 inch asphaltic sand.
14	....do	9	....do	Do.

GROUP C—CONCRETE.

Section No.	Grade of concrete.
1	1:1½:3, limestone aggregate.
2	1:1½:3, sandstone aggregate.
3	1:1½:3, granite aggregate.
4	1:1½:3, trap aggregate.
5	1:1½:3, gravel aggregate.
6	1:1½:3, slag aggregate.
7	1:1½:3, very soft sandstone aggregate.

Each section is 10 feet long and 2 feet wide, and is laid on a concrete base 8 inches in depth which in turn rests upon a 12-inch cinder subbase. Reinforced concrete curbs 6 inches wide by 30 inches in depth act as rigid supports on both sides and also serve to carry the rails on which the wear machine travels. Figure 3 shows the curbs in place and the compacted cinder fill ready for the concrete base.

WEAR BY HEAVY STEEL TIRED VEHICLES.

A wear testing machine has been designed to approximate the wear produced by heavily loaded steel-tired vehicles. It consists essentially of 5 cast-iron wheels 48 inches in diameter and 2 inches wide, each weighing 1,000 pounds. The wheels are mounted inside of a channel iron frame in such a way that they roll over the center 12 inches of the 24-inch test strip. Each wheel is mounted independently of the others so as to be free to move up and down and thus adjust itself to inequalities and depressions in the pavement along the line over which it travels. The wheels travel the length of a 400-foot section three times in two minutes, or at approximately 6 miles per hour. The amount of wear produced is measured by means of an Ames dial mounted on a straight edge which in turn rests upon plugs set in the sides of the section at various points along the test strip. This device is also used to measure the wear of various types of pavement under actual traffic.

If it is found that the abrasive action of the wheels is too slow, means will be provided for accelerating wear either by installing an arrangement to imitate

the impact produced by horses' hoofs or by allowing the wheels to roll off of a series of ramps arranged so that each wheel will drop a short distance before striking the pavement. After the abrasive tests have been run on all of the important types of pavement, it is planned to modify the machine so as to determine the shoving effect of fast-moving, rubber-tired wheels on various types of bituminous pavements.

DISTRIBUTION OF PRESSURES THROUGH EARTH FILLS.

An elaborate series of tests has been under way for several years for determining the distribution of concentrated pressures through earth fills. This is a problem in connection with bridge design and its solution will also be useful in questions of road design as well as for the design of footings and foundations. The measurement of the pressure exerted by earth or of the pressure transmitted through earth is an exceedingly difficult operation. The difficulty lies in the fact that the earth is not liquid but possesses a slight amount of elasticity and there is more or less internal friction and cohesion between the particles. Any instrument for measuring earth pressures must perform its function without appreciable movement of the instrument itself, for any movement of the instrument against or away from the earth either increases or decreases the pressure exerted by the earth.

In order to take care of these difficulties, a special diaphragm cell has been designed. These cells are buried in the fill wherever it is desired to ascertain the pressure and a small pipe is laid from the cell to a convenient position for taking measurements. The cell is designed so that when air is introduced into it through the pipe electrical contact is broken within the cell at the exact instant that the air pressure within equilibrates the earth pressure on the cell. The air pressure is read at that instant by means of a pressure gauge. Thus far, a large number of tests have been made for determining the distribution of pressures through sand fills in depths up to 5 feet.

The pressure exerted by earth back of retaining walls has long been the subject of speculation rather than certainty. A number of theories have been advanced for the purpose of calculating these pressures, but all of these theories are arrived at from a mathematical standpoint and are not based on sound experimental data. For the purpose of obtaining enough information to check up some of these theories, a series of tests has been started to determine the actual pressures being exerted against retaining walls. The procedure is to bury a number of pressure cells against new walls before the fill is made. After the earth fill has been placed, a series of readings of the cells are made extending over a period of more than one year. These results will finally be worked up in a form such that a rational theory for retaining wall pressures may be obtained. Thus far, the pressures back of two high walls have been measured.

SOIL STUDIES.

In connection with the distribution of pressures through earth, the physical laboratory is working on methods for determining the physical properties of soils. This includes a method for determining the relative bearing power of soils of different mechanical composition and different water-holding capacity and also rapid as well as accurate methods for the mechanical analysis of soil samples from the standpoint of their classification, use as road foundations or subgrades and as surfacing materials. The subgrade ultimately carries the load to which the road is subjected and when it is considered how greatly soils vary in their bearing capacity, the importance of this work becomes apparent. The laboratory is working in a new field along this line because studies of the physical properties of soils have been made so far almost exclusively for the purpose of agricultural analysis. A means for artificially compacting soil samples in the laboratory so as to approximate their conditions in nature has been worked out, as has also a more rapid and simpler method of analysis than has heretofore been used.

DISTRIBUTION OF PRESSURES THROUGH HYDRAULIC FILLS.

In the construction of large earth dams for impounding water as a means of flood control or for other storage purposes, recourse is had at the present time to the hydraulic fill method of construction. In this method the general procedure is to wash material from the bank, near the site of the dam, by means of powerful jets of water. This material may consist of large pieces of rock graded down through gravel and sand to silt and exceedingly fine clay. The water mixture of materials is carried by means of a flume toward the center of the dam. The very coarse particles deposit first and as the stream approaches the center of the dam the smaller particles settle until finally there is left a pool of muddy water extending across the valley in the center of the dam. As the sides build themselves up in this way the mud in the pool of water settles out and ultimately a clay core wall is formed in the center of the dam with sides composed of increasingly coarser material as they extend outward. In several instances these dams have progressed almost to completion when suddenly an entire side of the dam has been moved outward causing the loss of thousands of cubic yards of material and requiring an enormous amount of labor to continue the construction. The cause of these failures is the immense pressure exerted by the core wall which is still in liquid condition. The exact pressure exerted by

these core walls is unknown and it has been extremely difficult for engineers to design hydraulic fill dams on this account.

At the request of the Miami conservancy district the bureau undertook a series of investigations for determining just what pressure is developed in hydraulic fills such as occur in the center of hydraulic fill dams. For this purpose a standpipe was erected and the process of filling this pipe with very fine clay was conducted in a manner similar to the filling of the core wall of an hydraulic fill dam. Pressure cells were immersed in this clay fill during construction and readings have been taken extending over a period of practically two years so that much information has been obtained on the actual pressures exerted by hydraulic fills in depths up to 40 feet.

TESTS OF REINFORCED CONCRETE SLABS CARRYING EARTH FILLS.

In the past, reinforced concrete slab bridges have been designed under a variety of assumptions regarding the width of slab which should be considered as carrying a concentrated load. These assumptions were so variable that the thickness of slab obtained through their use was quite different for carrying exactly the same load. In order to obtain specific information on the design of slabs the laboratory started a series of reinforced concrete slab tests some six years ago. Enough information has been obtained to form a basis for the rational design of slabs directly supporting a concentrated load. An earth fill on top of a slab serves, however, to distribute concentrated loads so that the effect of the fill should be to increase the width of slab which may be counted upon to support the load.

In order to obtain exact data on the effect of the earth fill, a new series of tests will be started for obtaining the "effective width" of the reinforced concrete slab having different thicknesses of earth fill and subject to concentrated loads. The slabs will be 16 feet in span length and of various thicknesses and depths. The loading blocks will be shaped like the wheels of trucks and the test data will include strain-gauge measurements of the distribution of stress in the steel-reinforcing as well as earth-pressure measurements, in order to obtain the distribution of the concentrated loads through the earth fill to the slab.

DISTRIBUTION OF PRESSURES THROUGH ROADS.

A short investigation has recently been completed showing how a concrete road slab distributes a heavy superimposed load to the underlying subgrade. Numerous instances are at hand in which slabs, both of brick and of concrete, have failed particularly on soft subgrades when subjected to heavy traffic, and it was with the idea of obtaining some specific information on the slab action of such structures that this investigation was started. The soil pressure cells previously described were placed on the subgrade of a concrete road just before the concrete was deposited. After traffic was allowed on the road a heavy army truck loaded with 5 tons of sand and weighing 17,000 pounds on the rear axle was placed in particular positions with respect to these cells. In this way, the distribution of the concentrated loads to the underlying subgrade was measured. It was found that the greatest intensity of pressure occurred directly under the load and was equal to about 6½ pounds per square inch. The pressure vanished to 0 at a distance of 6 feet from the load so that, in general, it may be said that the load was carried by means of a cone pressure of 4 feet in radius.

On the basis of these tests, the stress in a concrete road 8 inches in thickness laid on a rather soft subgrade has been determined to be only about 34 pounds per square inch. In view of the low stress, investigations along this line have been discontinued as it is believed that the necessary strength of road slabs may be more correctly ascertained by subjecting them to impact rather than to static loads.

PRESSURES OF CONCRETE AGAINST FORMS.

The design of wooden forms for concrete construction involves a knowledge of the pressure exerted by the concrete in these forms. Such knowledge at the present time is rather uncertain and in view of the availability of instruments in this office for making such investigations and the obvious need for results of this character in the design of forms for bridge and wall construction, a short investigation has been practically completed showing the pressures exerted by concrete of different mixtures and consistencies. These results will be of value in aiding the concrete designer in properly proportioning the ties and braces in all form construction.

SLAG INVESTIGATIONS.

Throughout the country in the vicinity of the steel mills there are millions of tons of blast-furnace slag incidentally produced in the manufacture of steel. The slag has been deposited in huge banks and until recently much of it has been considered as having little commercial value. Lately, however, a great deal of slag has been used in the construction of roads and in the making of concrete and reinforced concrete structures. It has been claimed that in some cases the slag has given poor results and many engineers fear that on account of various chemical constituents of the slag rusting of reinforcing steel may result from its use as the coarse aggregate in concrete. It is also felt by some engineers that there is considerable danger that the concrete made from some slags will be unsound.

In view of the growing importance of the slag industry and the economic possibilities in its use for road and bridge construction, an investigation has been undertaken in order to determine just what physical and chemical characteristics slags should have in order to make them absolutely safe for structural purposes. These investigations have been begun by having representatives from the bureau take samples from most of the slag banks that are being worked in this country at the present time, obtaining information on the process of slag production and observing slag concrete construction. The laboratory investigations will involve crushing strength tests of concrete using slags of various weights from various localities, as well as a special abrasion test in the Talbot-Jones rattler made to determine the minimum weight of slag per cubic foot which should be allowed as coarse aggregate in concrete road construction. The effect of slag concrete on the preservation or corrosion of reinforcing steel is likewise to be undertaken and the ultimate aim will be to obtain all of the information necessary

for drawing safe specifications for slag wherever it is desirable to make use of it.

In addition to the investigation of blast furnace slags, a study is also being made of various smelter slags, of which there exist enormous quantities. These slags are being subjected to chemical and microscopic examination for the purpose of classification and when they appear to be suitable for highway work they are subjected to the ordinary tests for road-building rock. They are also used to make up concrete test specimens.

STANDARDIZATION OF COMMERCIAL SIZES OF BROKEN STONE.

In connection with the production of broken stone for highway purposes, a considerable amount of work has been done in connection with the standardization of commercial sizes. A survey of stone quarries throughout the country has been undertaken for the purpose of studying the details of plant operation as related to the character of output. Quarries in most of the section east of the Mississippi River have been covered and results of these investigations have been published. The work is being continued and it is hoped that the general adoption of certain standard sizes will soon be brought about and will remedy the present chaotic condition of the industry, both in the interest of the highway engineer and the manufacturer. The importance of this investigation may be illustrated by the citation of one instance in which it was found that owing to variations in the demands of engineers within a very restricted area, revolving screens with as many as 22 different size openings were being used to produce for all practical purposes 6 commercial sizes of broken stone.

INVESTIGATION OF COST OF PRODUCING BROKEN STONE.

A detailed study of the cost of producing broken stone is being made at a number of typical quarrying, crushing, and screening plants. Already sufficient data has been secured and worked up into such form as to be of very practical value, both to the commercial quarry operator and to the engineer or contractor who wishes to open up and work local deposits for individual jobs. This investigation involves comparisons of cost of various methods of drilling, blasting, breaking boulders, delivery, crushing, screening, pumping, and waste disposal, both at large and small scale plants.

INVESTIGATION OF ABRASION TESTS.

The physical laboratory is constantly engaged in the routine testing of all types of nonbituminous road materials but also undertakes various investigations in connection with laboratory methods. At present an extended investigation is under way relative to a modification of the standard abrasion test for rock. This also involves the development of a special abrasion test for stone block and the development of an abrasion test for gravel.

Although the Deval test has in general been considered fairly reliable, certain defects have recently been pointed out which indicate that it can be considerably improved. Among these may be mentioned the accumulation of dust inside the cylinder during test which, acting as a cushion, considerably decreases the amount of wear, especially in the case of the softer limestones and sandstones. Variation in the amount of wear are also caused by variation in the shape of the pieces composing the charge, and the length of time required for making the test. The laboratory is working on this problem in conjunction with the road materials committee of the American Society for Testing Materials and hopes soon to present a revised test.

A satisfactory method of determining the resistance to wear of gravel has not as yet been devised owing principally to the difficulty of obtaining samples for test composed of pieces of definite size. The fact that gravel fragments have round instead of sharp edges greatly reduces the amount of wear, as compared with broken stone, unless an abrasive charge is used. Tests are now being made to find out what sizes of gravel and what kind of abrasive charge should be used in order to obtain comparable results.

A modified abrasion test applicable to stone block is also being developed in the laboratory to meet criticisms of the Deval test which has been used heretofore for determining the resistance to wear of such material. The test will make use of small machine-broken cubes of stone, all of substantially the same size. The exact number of cubes to use in a test charge has not as yet been determined, but will probably be much smaller than the number used in the Deval test. It is planned to correlate the results of this test with the wear tests of stone block pavement sections which have been described.

INVESTIGATION OF BITUMINOUS MATERIALS.

In the chemical laboratory investigations are conducted relative to methods of testing bituminous materials in addition to regular routine work. The laboratory also cooperates in the planning and supervision of experimental bituminous construction and the preparation of typical specifications for oils, asphalts, and tars for various uses. Among the laboratory investigations now under way may be mentioned a study of volatilization tests for road oils and asphalts with reference to the amount of loss and the effect produced upon the residue. An investigation of the density and toughness of various bituminous aggregates is also being conducted, as well as one upon the effect of exposure on different bituminous materials.

A small experimental refining plant has been installed at Arlington Farm and an investigation of various refining processes is being conducted on typical crude petroleums which are used in the manufacture of road materials. At the present time there is available very little exact information upon the details of manufacture of petroleum products, the limitations of the various methods of procedure, and the final products which may be commercially obtained. Information of this character is very desirable, if not essential, in the intelligent selection of bituminous road materials and the preparation of specifications to secure the desired product.

FOR A PAVED ROAD SYSTEM.

Maricopa County, Ariz., by a vote of 14 to 1, favored a bond issue of $4,000,000 for road construction. The proceeds are to be used in the building of a paved road system.

ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS.

NOTE.—Application for the free publications in this list should be made to the Chief of the Division of Publications, U. S. Department of Agriculture, Washington, D. C. Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free. In applying for these publications the name of the series as well as the number of the publication should be given, as "Bureau of Public Roads Bulletin No. 32."

REPORTS.

Report of the Director of the Office of Public Roads for 1916.
Report of the Director of the Office of Public Roads for 1917.
Report of the Director of the Bureau of Public Roads for 1918.

OFFICE OF PUBLIC ROADS BULLETINS.

*Bul. 28. The Decomposition of the Feldspars (1907). 10c.
32. Public Road Mileage Revenues and Expenditures in the United States in 1904. 15c.
*37. Examination and classification of Rocks for Road Building, including Physical Properties of Rocks with Reference to Their Mineral Composition and Structure. (1911.) 15c.
*43. Highway Bridges and Culverts. (1912.) 15c.
*45 Data for Use in Designing Culverts and Short-span Bridges. (1913.) 15c.
*48. Repair and Maintenance of Highways. (1913.) 15c.

DEPARTMENT BULLETINS.

*Dept Bul. 53. Object-Lesson and Experimental Roads and Bridge Construction of the U. S. Office of Public Roads, 1912-13. 5c.
105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913
136. Highway Bonds.
220. Descriptive Catalogue of Road Models of Office of Public Roads.
230. Oil Mixed Portland Cement Concrete.
249. Portland Cement Concrete Pavements for Country Roads.
257. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
*284. Construction and Maintenance of Roads and Bridges, from July 1, 1913, to December 31, 1914. 10c.
314. Methods for the Examination of Bituminous Road Materials.
347. Methods for the Determination of the Physical Properties of Road-Building Rock.
*348. Relation of Mineral Composition and Rock Structure to the Physical Properties of Road Materials. 10c.
370. The Results of Physical Tests of Road-Building Rock.
373. Brick Roads.
386. Public Road Mileage and Revenues in the Middle Atlantic States.
387. Public Road Mileage and Revenues in the Southern States.
388. Public Road Mileage and Revenues in the New England States.
389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914.
390. Public Road Mileage in the United States. A summary.
393. Economic Surveys of County Highway Improvement.
407. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
414. Convict Labor for Road Work.
463. Earth, Sand-Clay, and Gravel Roads.
532. The Expansion and Contraction of Concrete and Concrete Roads.
537. The Results of Physical Tests of Road-Building Rock in 1916, including all Compression Tests.
555. Standard Forms for Specifications, Tests, Reports, and Methods of Sampling for Road Materials.
583. Report on Experimental Convict Road Camp, Fulton County, Ga.
586 Progress Reports of Experiments in Dust Prevention and Road Preservation, 1916

*Department supply exhausted

Dept. Bul. 660. Highway Cost Keeping.
670. The Results of Physical Tests of Road-Building Rock in 1916 and 1917.
691. Typical Specifications for Bituminous Road Materials.
704. Typical Specifications for Nonbituminous Road Materials.
724. Drainage Methods and Foundations for County Roads

OFFICE OF PUBLIC ROADS CIRCULARS.

Cir. 89. Progress Report of Experiments with Dust Preventatives, 1907.
*90. Progress Report of Experiments in Dust Prevention, Road Preservation and Road Construction 1908. 5c.
*92. Progress Report of Experiments in Dust Prevention and Road Preservation, 1909. 5c.
*94. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1910. 5c.
98 Progress Reports of Experiments in Dust Prevention and Road Preservation, 1911.
*99. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1912. 5c.
*100. Typical Specifications for Fabrication and Erection of Steel Highway Bridges. (1913.) 5c.

OFFICE OF THE SECRETARY CIRCULARS.

Sec. Cir. *49. Motor Vehicle Registrations and Revenues, 1914. 5c.
52. State Highway Mileage and Expenditures to January 1, 1915.
59. Automobile Registrations, Licenses, and Revenues in the United States, 1915.
62. Factors of Apportionment to States under Federal Aid Road Act Appropriation for the Fiscal Year 1917.
63. State Highway Mileage and Expenditures to January 1, 1916.
65. Rules and Regulations of the Secretary of Agriculture for Carrying out the Federal Aid Road Act.
72. Width of Wagon Tires Recommended for Loads of Varying Magnitude on Earth and Gravel Roads.
73. Automobile Registrations, Licenses, and Revenues in the United States, 1916.
74. State Highway Mileage and Expenditures for the Calendar Year 1916.
77. Experimental Roads in the Vicinity of Washington, D. C.

FARMERS' BULLETINS.

F. B. 338. Macadam Roads.
505. Benefits of Improved Roads.
597. The Road Drag.

YEARBOOK SEPARATES.

Y. B. Sep. *638. State Management of Public Roads; Its Development and Trend. 5c.
727. Design of Public Roads.
739. Federal Aid to Highways.

REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH.

Vol. 5, No. 17, D-2. Effect of Controllable Variables Upon the Penetration Test for Asphalts and Asphalt Cements.
Vol. 5, No. 19, D-3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.
Vol. 5, No. 20, D-4. Apparatus for Measuring the Wear of Concrete Roads.
Vol. 5, No. 24, D-6. A New Penetration Needle for Use in Testing Bituminous Materials.
Vol. 6, No. 6, D-8. Tests of Three Large-Sized Reinforced-Concrete Slabs under Concentrated Loading.
*Vol. 10, No. 5, D-12. Influence of Grading on the Value of Fine Aggregate Used in Portland Cement Concrete Road Construction. 15c.
Vol. 10, No. 7, D-13. Toughness of Bituminous Aggregates.
Vol. 11, No 10, D-15. Tests of a Large-Sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.

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